SEP 22 1924

McGraw-Hill Company, Inc.

September 20, 1924

Twenty-five Cents Per Copy

ENGINEERING AND MINING JOURNAL-PRESS

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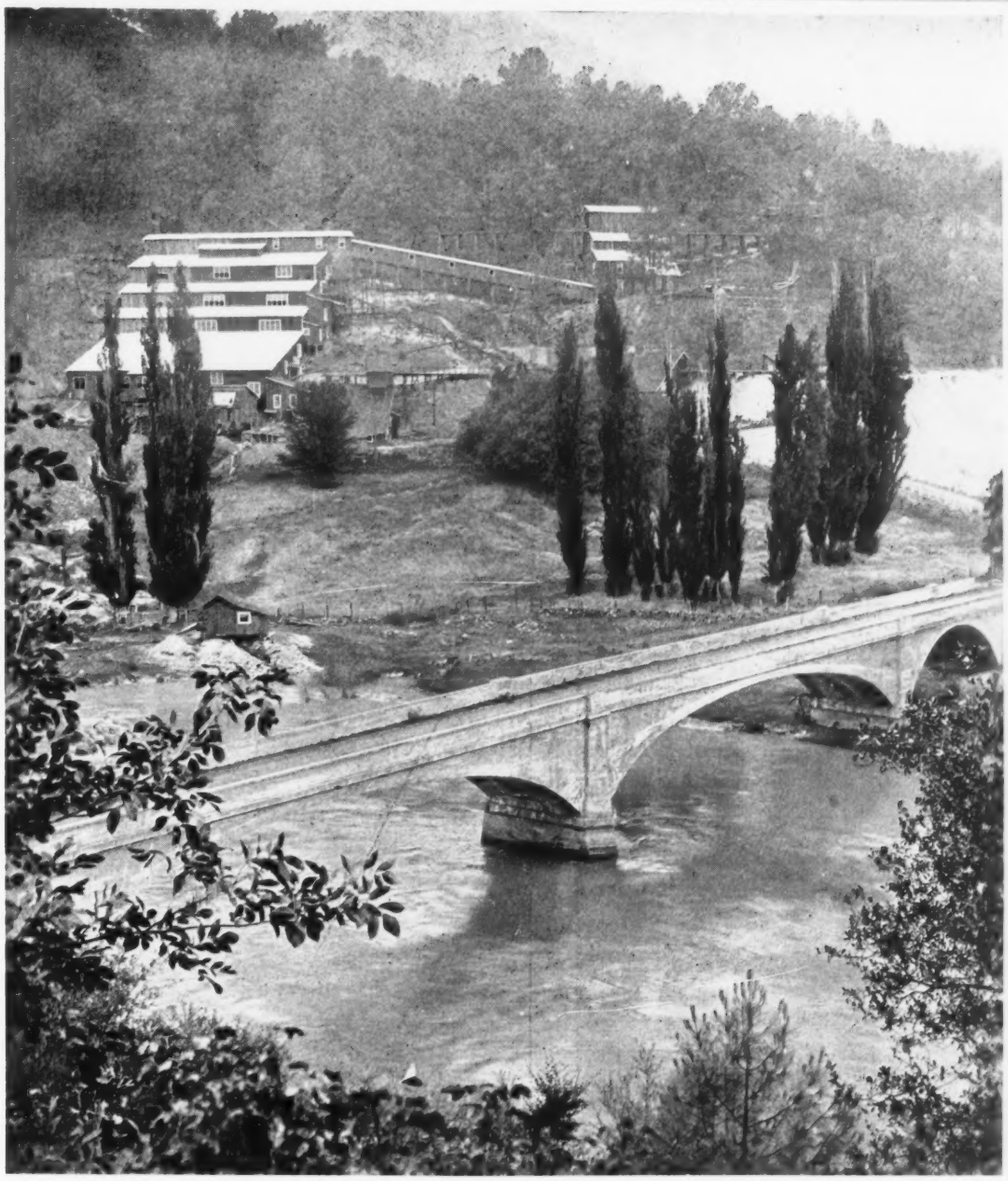

A gold mine on the Mother Lode in California

The Return to Normal of the Copper Industry, by Arthur Notman

Factors in Mine Cost Accounting, by Benjamin F. Tillson

France—Its Attitude Toward Germany—Its Reconstruction Achievement, by E. J. Mehren

Selective Flotation at Nacozari, by William T. MacDonald

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ENGINEERING AND
MINING JOURNAL-PRESS

JOSIAH EDWARD SPURR, Editor

Volume 118 | New York, September 20, 1924 | *Number* 12

Europe

THE CONDITION OF EUROPE is one of the important factors to consider in evaluating the future of the mining industry: for upon European economic health depends Europe's capacity to absorb our mineral products. Copper men returning from a sojourn in Europe—men like Stephen Birch, president of the Kennecott company—have augured favorably for the future copper market, from the operation of the Dawes plan and the favorable outlook for Germany and other nations. The series of articles on general conditions in England, Germany, and France (the last of which we publish in this number) by Mr. E. J. Mehren, vice-president of the McGraw-Hill Co., will be read with interest and are valuable reflections. The recent changes, as reported, are greatest and most favorable in Germany; the economic condition of England is grave; France still is in sore straits, but the ultimate outlook is good. Germany has reverted to the gold mark and emerges in a healthy financial condition, without debts (except the Reparation debt), but without honor, since by her financial policy she has rendered void all the vast internal debt she had created and which was owed to the citizens of Germany and other countries. England, sound financially, scrupulous and honorable in her debts, is cursed with a system of doles to the unemployed, and is in no strong economic position. France has done a wonderful job of reconstruction.

A number of the representatives of the McGraw-Hill Co. inspected Europe during the past season. The general composite picture brought back indicates encouraging progress; it also clearly indicates a Europe further retrograded in essential civilization than before the war. The war was fought in vain; it was a net loss; the world has not been made safe for democracy —not even safe for mankind under any form of government. The tendency toward isolation of states, toward national and racial hatreds, toward the multiplication of tongues, has been vastly increased. Europe has gone backward. "Europe," said Premier MacDonald of England the other day, "in the last few years has not offered America a very attractive companionship." In truth, no. And yet it is a companionship which exists, attractive or no; we cannot avoid the companionship. The world has become too small, too closely knit, for that.

One repeated comment on Europe (from those who enjoyed the wines abroad) is that Europe (including England) eats and drinks too much; and they suggested prohibition as a wise economic reform. Page Pussyfoot Johnson, who lost an eye preaching prohibition to the English workmen; and evoke the shades of Mohammed, the father of prohibition, who may yet live to see his principles of abstinence triumph over a world of Franks which his sword wearied in subduing.

Lead and Zinc Values

THOSE OF OUR READERS who glanced at last week's market report may have noticed a peculiarity that has prevailed for many weeks, but which has not been generally so striking as in that particular report. We refer to the London lead and zinc quotations. They might have been interchanged without being much out of line. Lead and zinc in London during that week was worth each day about the same value—£33⅛ for spot and £32¼ for three-months metal. Only small fractional differences per ton separated the two prices, 2s. 6d. to 10s. per ton. At the same time it is instructive to observe that the St. Louis lead and zinc markets were separated by about 1¾c. per lb., with lead worth about 7.85c. per lb. and zinc, 6.175c. The varying relation of these two metals in American and European markets may, of course, be easily explained by the effect of the tariff on importations into the United States. Inasmuch as no tariff exists on the importation of these metals into Great Britain it is fair to assume that the London prices are more expressive of the actual world value of lead and zinc than the New York or St. Louis prices. In other words, lead and zinc are about equal in value at present, allowing for the influence of tariffs.

Incidentally, these price relationships are splendid examples of the changed condition of some commodity values as compared with the pre-war status. Whether this is temporary or permanent is an interesting speculation.

Chile and Copper Taxes

OUTSIDE of a natural interest in the internal affairs of a friendly country, the chief concern of the mining interests of the United States in the political difficulties of Chile lies in their possible effect on the mining industry there, particularly as to copper. Both the Chile and Braden companies are, of course, owned largely by investors in this country. Those best acquainted with the situation in Chile are of the opinion that the inherent conservatism of the people will enable them to weather this crisis without resort to arms and without any interference with industries such as copper and iron mining and nitrate production.

However, out of the readjustment of affairs additional taxes are likely to emerge. This will have some bearing on the cost of copper and all other commodities other than the products of the soil. Just what form new taxes may take is speculative. It is significant that when the new incomes tax law was adopted—the tax is now being collected for the first time—nitrate producers, who pay a considerable tax on exports, were specifically excluded from its provisions. The inference was that the legislators felt that one tax was sufficient. Copper-producing companies, which now pay no export tax, as well as

other corporations and individuals, are subject to the income tax. However, the seed of the present difficulty seems to lie in financial trouble, so that a rearrangement of sources of revenue would not come as a surprise.

The selection of Arturo Alessandri for the Presidency is said to have been in recognition of a growing demand from the masses for a more representative form of government. When a candidate for office, Mr. Alessandri promised a large expansion in the school system and an ambitious welfare program. This called for expenditures in excess of the country's income. In order to make both ends meet, he has been reducing the appropriations allowed the army and navy, which are said to have been the pets of previous administrations. The break with the military, resulting in the deposing of Mr. Alessandri, came finally when, it is said, the appropriation for the pay of personnel was diverted for school construction.

The administration of affairs in Chile is said to have been conducted for a long period of years by the representatives of eighty families. Even if the entire population does not have a voice in government, the task has been well done, it is contended, since more than a century has passed without a single revoluntionary disturbance in the country. When there have been political crises in Chile before, unusually good judgment has been displayed in their settlement. For that reason it is believed the present squall will be weathered without interference with industries, but it is anticipated that the welfare program will have to be continued, which means additional taxes. Any tax increase is expected to be drawn largely from the mineral industries, as the large land owners of the country are in a position to prevent any such levy on them.

Too Much Reading Matter

ONE OF THE MOST ASTOUNDING pieces of extravagance which characterizes present-day life is the prodigality of paper and printer's ink. Statisticians and psychologists, economists and sociologists, might well begin a series of monographic studies on the subject, which it is easy to foresee would run into very many thick volumes of reports, involving much paper and ink, for the problem is a complex one. The madness for publicity is such that our forests are being consumed by the fierce holocaust. Printers demand and receive the highest pay of all industrialists; editors—but we are digressing.

It requires a violent effort of detachment to write judicially on a business of which one forms a part. Nevertheless, it is evident that, among the causes of Industrial Waste which have recently been stigmatized and investigated, the waste of manifolded printed language is one of the clearest and most flagrant cases. One of the most striking instances of Industrial Waste was the thick report on the subject published by the committee of the Federated American Engineering Societies. No one can go out and buy four Sunday papers on a Sabbath morning and trudge wearily home with his heavy burden, without having a depressing sense of guilt—of connivance in despoiling the Republic, and scrambling the brains of the 100 per cent American—of economic and psychologic dereliction.

One knows that there is too much stuff published. No person so lowly, no brain so puerile, that his thoughts and measly jokes may not be starkly set forth in print and broadcast by thousands. No one knows, these days, much about literature, as they did in the Victorian days and pre-Victorian days. It is nowadays an immensity, like the stars of heaven. The newspapers, the *Congressional Record*, the proceedings of the scientific and technical societies (whose name is legion), the technical journals, the newspaper and society proceedings, we repeat, are replete with thousands of pages of printed stuff that suggests to us a theory that the typical writer has long ago given up any expectation of being read—the material is printed for his own edification and without hope of help from the reader.

This is a long-standing thought with us. The sense of being engaged in a questionable occupation colors our acts, leads us to cut down letters sent for discussion, to reject otherwise worthy manuscripts, refuse to print news items the seventh time, after they have slipped in under different guises six times. There is no suspicion of being pharisaical in this attitude: we do not thank God we are not as other men are. We humbly confess we are what other men are—poor worms of futility and extravagance of paper and ink, as witness this present editorial. At our hand happens, however, to lie a report of the proceedings of the American Mining Congress, Twenty-sixth Annual Convention, 1923, 793 pages. Of course, neither Mr. Callbreath nor any of the officers of the Congress have any idea that anyone will ever read these 793 pages, or, probably any part of them—except the contributors, possibly but improbably. Personally, we never read our own stuff after it is in print—we can't stand it—and we find human nature about the same. This A.M.C. report lies open accidentally. We glance at the page and read: "When I cross on the ferry in my home town in San Diego to Coronado, I watch the jelly fish: there are a lot of them." Enough of that—there is some poetry lower down the page:

> "Under the spreading chestnut tree
> The village smithy stands.
> The smith a mighty man is he—"

Hold, enough! We violently turn a couple of hundred pages, more or less, and read:

"Chairman Alderson: I think this is important enough for a formal resolution of thanks to be made. I will entertain a motion that our thanks be tendered to Senator Phipps for his able article and that those thanks be transmitted to him by the chairman of the conference, unless somebody will take it upon himself to put that in better language," etc.

The use of the "etc." quoted as above is tabooed by our style book and our copy editor; but there are exceptional cases.

Literature of Commerce

WE SOMETIMES WONDER if the average trade catalog is as fully appreciated as it deserves to be. Not only is it often a work of art, but it frequently contains much expert information to be found nowhere else. Compilers and writers of textbooks and handbooks would probably find themselves greatly inconvenienced were this handy source of facts and data suddenly denied them. Not so long ago some one inquired if we knew of an institution that maintained a library of catalogs. We do not, though there may be several. At any rate, the idea is not so bad. The collection of catalogs might be justified, at least as readily as the collection of postage stamps,

which are oftentimes issued in new and ever changing designs simply to keep collectors busy, and it would have a more practical value. In the long list of publications issued by more than one important manufacturer is written the history of the development of the particular line of machinery—hoists, pumps, compressors or whatever it may be that he makes. But in the main, the catalog, artistic, informative and expensive though it be, too frequently is accorded but a transient value. The catalog of today pushes that of yesterday out of our recollection and will in turn be supplanted by the catalog of tomorrow, to paraphrase a familiar sentence. They are made to sell goods and, if successful, have fulfilled their destiny, even though they end their days on a rubbish heap. As silent messengers of the manufacturer, their costly typography and elaborate covers correspond to the jaunty attire and expensive habits of the average traveling salesman, impressing those who deal with them. The labor expended in preparing them is never lost, from the manufacturers viewpoint, if they sell the goods.

Foreign Inclusions in Veindikes

THE CONCEPTION that fissure veins are in many cases veindikes; that they are due to the injection of a substantial magma, which has distended the fissures and froze in them, essentially as is the case with dikes, is so novel and revolutionary as to cause instinctive recoil among those who have long accepted as axiomatic that fissure veins are built up slowly by precipitation from waters—hot or cold. It is natural that this recoil should be most marked among those who have devoted most arduous labor to the subject, and who accordingly are in the condition of having their fundamental conceptions long and deeply rooted. Yet the mental elasticity of many of these veteran professionals is shown by their having accepted the proofs of the veindike theory, or at least recognized that the theory is so apposite to the facts that it must be carefully considered. This is a healthy mental condition. The missionary of any faith stands no show of a hearing at an assembly of the priesthood of any other religion; his best audience is with the young and considerate.

It is inevitable therefore that against the veindike or ore-magma theory many arguments, reasonable or strained, will be brought by those who object to having their scientific faith's foundation undermined—and who of us does not naturally resent that?

The inclusion of angular fragments in the material of fissure veins is in many cases proof of their veindike origin. Some of these phenomena may be explained by replacement rather than injection: most of them cannot thus be reasonably explained, yet may be forced into this Procrustian bed of explanation. But when one or more of the included angular fragments in the vein is of material foreign to both wall rocks at the point found, then the replacement hypothesis must needs be abandoned by the most persistent. Such cases are not uncommon—cases which show that included fragments have moved, along with the vein magma, from their original locations to find rest in the places where we find them. Veins have been little examined from this point of view, however; and it is beiieved that there are many good instances which might be observed, and this would helpfully swell the records.

We make a special request, therefore—and that is the object of this editorial—to engineers and geologists who have occasion to study fissure veins, to be on the lookout for cases where one or more included fragments differs from both the immediately adjacent wall rocks; and kindly to write the editor of the circumstances of such occurrences, with photographs or sketches. Some such foreign inclusions may indicate transportation for only a few feet, or a few score feet; while some instances are on record where rock fragments have been carried upward thousands of feet, borne along by the ore magma as it welled up into the fissure. Will you not study your own examples, and advise if you find clear phenomena of this kind? It will advance science.

The Cost of Mineral Products

THE CONSUMING PUBLIC that indirectly or directly uses metals or minerals and the products manufactured therefrom does not appreciate the effort that is necessary to supply them with these necessities. For every successful enterprise there are many that do not succeed. Nevertheless, the cost of these unsuccessful enterprises is a factor in the mining industries. In many instances this cost does not appear in the selling price of the metal or other product, but is directly assumed by the individuals who have failed to develop a remunerative property.

Markets seldom reflect costs of production, but predicate their prices upon the law of supply and demand. Thus, the public has the advantage in that it may frequently buy its metal and mineral products at prices below the cost of production. There is no practicable way to superimpose upon consumers the capital losses due to unsuccessful ventures except in the instance where a mining company engages in a number of enterprises and carries its unsuccessful efforts by utilizing in part the profits from its successes.

The Standard Oil Co. (California) engaged in a five-year effort to find oil on the Bondoc Peninsula, Island of Luzon. A million and a quarter dollars was spent. The effort was undoubtedly a conscientious one, but the wildcat remained a wildcat, in spite of good engineering and well-applied geology. The dent put into the finances of the company was a small one, and other unsuccessful wildcat ventures have left similar dents. However, in this instance the venture appears as an element in the cost of production, no matter how it may appear in the final accounts of the company.

Except such notable exceptions as Anaconda and a few other mining companies, metal-mining companies begin with a single venture and continue, if it is successful, or, if not, automatically disappear. In the latter case individuals have carried the losses. In the aggregate the failures outnumber the successes, and the total average annual loss contributed to the industry must be a relatively large one.

We believe that the miner is entitled to a far greater consideration by the public than he gets. Out of the successes and failures of mining, a tremendous stream of raw materials flows into the industries and gives opportunity to workers and many other individuals. Our prosperity is dependent in part upon the maintenance of this flow. Without the co-operation of the consuming public and sympathetic understanding the miner will drift into other fields, and the resulting leanness in metal and mineral supplies will greatly enhance prices.

France—Its Attitude Toward Germany

Its Reconstruction Achievement

By E. J. Mehren
Vice-President, McGraw-Hill Co., Inc.

COMING to France after visiting Germany and noting there the transformation of spirit and the indications of reviving strength, one naturally asks whether the French, if aware of these developments in Germany, are formulating a policy that will work toward a peaceful solution of their differences. As everyone knows, the French policy to date, no matter how justified to the French mind as a means of forcing reparations or insuring security, has built up a hatred of the French in Germany. Such a feeling, taken in connection with the growing strength east of the Rhine, bodes no good for Europe.

Do the French realize what has happened in Germany? Do they foresee the possible results of the growing enmity? What policy are they formulating that will, peacefully, meet the situation?

These are questions that force themselves on the visitor who, leaving Germany, comes to France.

Moderate Policy Developing

The French do realize what has happened in Germany; they are watching Germany more closely than is any other nation. The result is what might be expected of men who do not blind themselves to the facts; a growing opinion that France must develop a harmonious relationship with Germany. The view is not yet very articulate, but Herriot's more conciliatory attitude, as contrasted with Poincaré's, is tangible evidence of the growing feeling. Force is seen to be ineffective; the invasion of the Ruhr is concededly a blunder.

The more friendly development, it is felt, should begin with commercial treaties, possibly commercial alliances. The German steel mills in the Ruhr, for example, can get their cheapest iron from Lorraine, now a part of France; Lorraine, on the other hand, needs German coal and can find the best market for its iron in the Ruhr. What more logical, then, than to come to agreement and to facilitate the co-working of these economically allied iron mining and coal and steel producing districts? The last election showed that the French want to try a new method of dealing with Germany; and the tide, judging by what could be learned here in Paris, is still setting away from Poincaré and toward the development of amicable relations.

Repeatedly, in discussing these matters, it was impressed upon the visitor that France has no commercial jealousy of Germany, and that her sole desire is for security against German aggression. Security she does want, and until she gets it, through agreement with other nations or German alliance, it will be the controlling motive of French policy.

Admiration was recently expressed in these letters over developments in Germany. But no less should be the admiration of the French; they have done a mighty work in rebuilding the devastated regions of their country.

Four years ago I stood in Lens, on the site of the Hotel de Ville (the city hall), and surveyed in every direction the worst destruction I had seen anywhere in France. This week I stood on the same spot. Round about was an entire new city, housing as many people as before the war. There were gaps here and there, where new buildings have not replaced the old; there is work under way in almost every street, on pavements, or sidewalks, or services; there are large buildings still under construction, new churches, and two banks; but for practical purposes it is a complete town, a town resurrected and at work—resurrected and at work where only desolation had reigned four years ago.

Striking as is the impression within the city of Lens itself, the impression is even stronger when one motors to the heights of Notre Dame de Lorette (where 100,000 French soldiers gave their lives during the war) and looks down upon the whole area. The landscape as far as one can see is dotted close with new red-roofed towns, each surrounding the shaft of a single mine.

Of course, the scars of war are still visible. Remains of trenches are found in Lens and in the country round about, while from the tipple of No. 11 shaft one can trace the wide swath of waste land—No Man's Land—where ran the main trench line, established when the English took Loos in the terrific fighting in September, 1915.

Much remains, too, to be done in the way of completing the reconstruction. Sidewalks are missing in large part. Many streets are unpaved or only temporarily paved. The churches and the municipal buildings are in hand only now or not yet started, the first efforts being put upon the recovery of the mines and upon housing. Probably two years more will be needed in the Lens district to finish the work.

Mine Reconstruction

To reinforce the general observations about progress, a few statistics will be given. The company operating the Lens concession (sixteen mines) will be taken as an example. The Lens company before the war employed 12,300 men underground and mined 370,000 metric tons of coal per month. On May 1 of this year, 10,458 men were at work underground, and the monthly tonnage was 175,000 (working conditions are still quite unsatisfactory). Of the 8,300 houses for workmen, 7,490 have been rebuilt, and the population of the mine towns (32,250 in 1913) is now 30,284. Thirteen out of the twenty-three destroyed working shafts have been repaired, the headworks completed and put in service, and so have eight out of the twelve ventilating shafts. Of 35 million cubic meters of flooding water, 31 million have been removed.

For French coal mines as a whole, the reconstruction figures show even greater progress than that of the Lens company. Of 200 mines destroyed, 145 are again producing coal, some of them, however, with temporary installations.

In the rebuilding of the tipples, electric substations, wash-houses for the workers, and the other necessary structures, the best construction and the latest equipment have been employed, so that the Lens area has the unique distinction of a whole district modernly equipped. The plant layouts are impressive for their substantial character and the entire absence of the timber structures and shabby buildings so characteristic of our mines. All the buildings are of brick, both the mine structures and the workers' homes.

General Reconstruction

This picture of reconstruction is matched in every part of the destroyed area; in many districts, of course, there were no industries, so that this side of the Lens development is missing. For the whole of the destroyed region the figures stand as follows:

	Total Work to Be Done	Finished Jan.1, 1924
Houses and farm buildings	741,900	605,900
Farm land to be reclaimed, hectares	1,923,000	1,788,000
Factories to be rebuilt	22,900	20,872
New roads, kilometers	58,697	42,360
Railroad and other engineering structures.	6,125	4,800

Finally, the population of these areas, which had before the war been 4,690,000 and which had declined to 2,075,000 at the time of the armistice, has now risen (figures of Jan. 1, 1924), to 4,253,000.

One other comment needs to be made that the appreciation of the French accomplishment may be complete: France has, herself, raised practically all the money required for this reconstruction. Her reparation receipts from Germany have covered only a relatively small part of the cost.

This is a great accomplishment and one that explains the French insistence upon reparation payments. She was the chief sufferer, and if her budget is now unbalanced it is because of her reconstruction charges. No wonder, then, that Poincaré had a following in a people who have placed upon themselves this very heavy burden. Let it be remembered, too, that in the wrecking of these regions France lost heavily of her income, for while the destroyed area was only one-fourteenth of the whole of France, it produced one-fifth of the income from taxes. Yet with these handicaps—diminished taxation, no outside financial help and a war-tried people—France has rebuilt her devastated regions. For practical purposes, the task is done. In four years her destruction has been repaired. Full economic and social life has been restored in territory wrecked beyond any other in history.

Paris, Aug. 25.

Selective Flotation at Nacozari

Scientific Research Applied to Mill Operation That Resulted in Significant Metallurgical and Economic Improvements

By William T. MacDonald[1]
Mill Superintendent, Moctezuma Copper Co., Nacozari, Sonora, Mexico

William T. MacDonald

THE TERM "selective flotation" is used loosely. Any process of concentration is selective in the sense that the words "selection" and "concentration," as applied to ore dressing, are often synonymous. In this paper, selective flotation is taken to mean the recovery of a flotation concentrate approximating in copper content the maximum fixed by the theoretical chemical constitution of the copper minerals that are here under consideration.

Selective flotation, in this sense, between chalcopyrite and pyrite, has been achieved in the mill of the Moctezuma Copper Co. at Nacozari, Sonora, Mexico, to the extent that over 90 per cent of the iron combined as pyrite in the original mill feed is now being rejected, whereas the percentage of copper recovered remains almost at the high level obtained when but 25 per cent of the pyrite iron was being rejected. With the treatment of ore of uniform character, the concentrate recovered has been gradually improved in average grade from 12 per cent copper, 32.5 per cent iron and 18.5 per cent "insoluble," for the operating year 1922, to an average grade for the last few months of 28 per cent copper, 29 per cent iron, and 8 per cent "insoluble." The sulphide portion of this concentrate approaches the composition of pure chalcopyrite, the atomic copper content of which is 34.5 per cent. Gravity concentration has been discontinued; and the improved metallurgy of the single-process, all-flotation flow sheet has increased the net financial saving by somewhat over 50c. per ton milled. This paper purposes to give a brief summary of the methods developed to obtain these results.

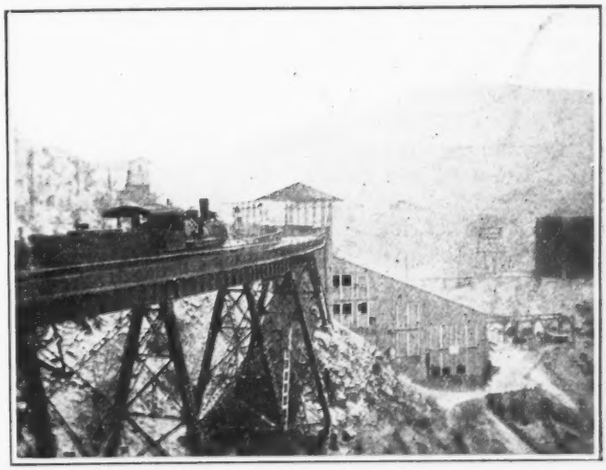
Location, Early Operations, Character of Ore

The property near Nacozari, 75 miles south of Douglas, Ariz., has been owned by the Phelps Dodge Corporation since 1895. A standard-gage railway, completed in 1904, connects Nacozari with the Copper Queen smelter of the corporation at Douglas. The principal mines of the company are at Pilares de Nacozari, 5.28 miles from Nacozari, and connected therewith by a company-operated narrow-gage steam railway.

The first mill at Nacozari, built in 1904, was replaced in 1908 by a 2,000-ton plant, at that time considered the finest in the Southwest. The introduction of flotation, together with the changing character of the ore with depth, necessitated a departure from the old style of jigs, tables and vanners. Changes were made, particularly in 1916 when the roughing tables replaced the fine jigs.

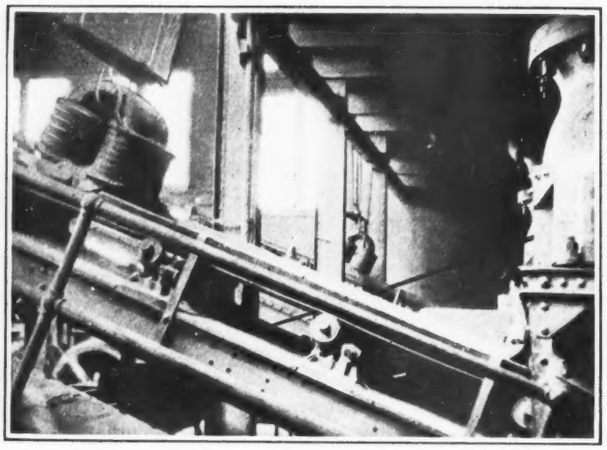
In 1918, the flotation experimental work, begun in 1914, resulted in a decision to remodel the plant. This was done in 1921-22, and amounted to the construction of an entirely new mill on the old site, designed by H. Kenyon Burch, who had also designed the previous plant, constructed in 1908. W. B. Cramer assisted Mr. Burch in determining the proposed metallurgy. Steel and concrete construction was employed throughout, and the existing foundations and floor levels were utilized so far as practicable. C. B. Clyne, representing Mr. Burch, was in charge of the construction work of the project.

The gangue of the upper-level ore is a latite, and that of the lower-level ore is an andesite. Both of these are hard—increasingly so with depth. The latite and andesite flows have been cut by intrusions of monzonite, diorite and quartz porphyry. The chief mineral is chalcopyrite, accompanied by minute quantities of chalcocite, covellite and bornite. About 0.08 per cent of acid-soluble copper is present. Associated with the copper minerals are large amounts of pyrite, almost free of copper, and some sphalerite, hematite and magnetite. Silver, averaging in some places 1 oz. per ton, occurs principally with the chalcopyrite. The value of the gold does not exceed four or five cents per ton. The analysis of the ore treated during the last two years has averaged from 2.5 per cent to slightly over 3.0 per cent copper, 11 per cent iron and 70 per cent "insoluble,"



Approach to coarse-ore bins at Nacozari

[1]*Note by Author*—This paper was originally prepared at the request of the management of the Moctezuma Copper Co. for a summarized report briefly covering the subject of selective flotation at Nacozari, for private information and files. As submitted, it contained complete information as to tonnages treated, copper content of the mill products, the percentages of copper recovery and other pertinent figures. When it was decided to permit the publication of the paper, it became necessary to curtail materially the detailed information and to eliminate some of the important data, to conform with company policy.



Suspended electro-magnets in coarse-crushing plant

corresponding to about 9 per cent chalcopyrite and 14 per cent pyrite, 1 per cent iron being present in the form of ferrosilicates.

Mill Was Designed for Concentration-Flotation Treatment

The new mill, as completed in 1922, consists of three 1,000-ton units. The redesigned coarse-crushing plant consists of two identical halves, each with the following equipment: one No. 8 McCully gyratory crusher, one No. 4-F Telsmith reduction crusher, and one 48-in. Symons vertical disk crusher. The McCully is preceded by bar grizzlies, and the Telsmith and Symons by Burch ring grizzlies. All but the McCully have magnetic protection against tramp iron. The capacity of the coarse-ore bins is 1,800 tons; that of the fine-ore bins, 8,000 tons. Both are discharged by Webster pan conveyors. The average size of the coarse-crushing plant product is now about 35 per cent on ½ in.

The essential equipment provided on each of the three units of the concentrator comprises two 6x12-ft. Marcy primary rod mills to grind the product from the coarse-crushing plant to 10 mesh; one 6x20-ft. Dorr desliming classifier, with overflow going direct to flotation; twelve Deister Plat-O roughing tables, which were expected to remove 50 per cent of the copper in the desliming classifier sands in the form of an 11 per cent concentrate, for shipment to the smelter; two 4 ft. 6 in. x 18 ft. 4 in. Dorr dewatering classifiers, handling roughing-table tailing; two 6x12-ft. Marcy secondary rod mills, each in closed circuit with one 6x23 ft. 4 in. Dorr classifier, to reduce the roughing-table tailing to 48 mesh for flotation treatment. The flotation equipment of each unit consists of four rows of Callow rougher machines, each containing 10 cells with 42x42-in. canvas air bottoms; two 6-in. air lifts to return the rougher concentrate to four rows of cleaners, of three similar cells each, at the feed end of the four rows of roughers, for one stage of cleaning. The depth of cell, from the froth-overflow lip to the canvas air bottom, varies from 17 in., at the upper end, to 26 in. at the lower end of each row of 10 rougher cells; and from 27 to 28 in. for the cleaner cells. The once-cleaned flotation concentrate was to be thickened and filtered for shipment to the smelter, and was expected to average 14 per cent copper. A neutral flotation circuit was contemplated. Twenty Deister Plat-O finishing tables were provided on each unit, to treat flotation tailing, to make a 3.5 per cent copper concentrate, and to give a general mill tailing of 0.23 per cent copper. The general mill concentrate was estimated to average 11.95 per cent copper. The absence of all intra-process thickening tanks, except for the handling of finished concentrate, is a noteworthy feature. The original flow sheet and the early results are shown in Fig. 1 on page 448, compared with various steps of subsequent development.

The first unit of the new mill was completed and commenced operation in strict accordance with design on June 1, 1922. The second and third units were placed in service on Aug. 1 and Dec. 15, respectively, of the same year. It is worthy of special note, and an indication of the splendid design and general excellence of mill-construction work, that no mechanical troubles of a serious nature have developed.

During the seven operating months of 1922 the average metallurgical results obtained were slightly better than those predicted. Original estimates called for an average final mill tailing of 0.23 per cent total copper and an average final concentrate of 11.95 per cent copper. The actual averages for this period were 0.22 per cent total copper in the tailing and a concentrate averaging 12.07 per cent copper.

The present summary of activities at Nacozari will naturally center about flotation, because the flotation process is the focal point of mill operation. However, the following notes are first included, to give brief information as to various other features of the mill with which the flotation department must at all times be co-ordinated.

Cast-Iron Cubes Used as Grinding Media

The flotation feed is reduced to an average of 12 per cent retained on 48 mesh, and 52 per cent through 200 mesh. The speed of primary and secondary mills is 17.5 r.p.m., except for two primary mills, under test, operated at 15.5 and 16.5 r.p.m., respectively. The slower speed is not proving entirely satisfactory. Mill liners are cast locally; the consumption per ton of primary mill feed is about 1.6 lb., including scrap loss, which is 30 to 35 per cent of the original weight. The total rod consumption for 1923 averaged 2.32 lb. per dry ton of primary mill feed, including the 10 per cent scrap loss. A standard 3 in. x 12 ft. straight-carbon (0.9 to 1.1 per cent) steel rod is used, although numerous other compositions are under test. An 18-ton rod load is usually carried. The primary mills have a 33-in. discharge opening. The discharge opening of the secondary mills has been reduced to 18 in. and some of them to 16 in. with a saving of about 5 per cent in power input to the mills. The primary mills are equipped with gravity chute feeders; the secondary ones with revolving scoop feeders.

A new grinding medium, the so-called cube, has been under investigation in two of the secondary mills for several months. Results have been sufficiently favorable that other mills are to be similarly charged in the near future; 3-in. cubes are generally used, cast locally of scrap iron. This modified cubical form was chosen from among the various shapes of flat-faced polyhedra included within the general specifications covering these grinding media, after consideration of the several conditions involved. Flat-surfaced rods of polygon cross-section offer possibilities which were given some consideration by me a few years ago. These cube mill tests have been under close observation since their com-

mencement and many detailed data have been compiled under conditions existing here. However, since the additional principle of a multiplicity of bucking-boards, as exemplified by the cubes—or certain other flat-faced polyhedra, represent a radical departure from long-established tube-mill practice, it is deemed advisable that no detailed data should be made public until the present experiments shall have extended over a sufficiently long period to have included the effect of temporary or variable factors in a fair average.

Screen analyses of mill products are made each month, from which the relative mechanical efficiency of the grinding machines may be calculated and from which the recovery of copper at each mesh size may be determined (see Table I).

Tailing Disposal, Mill Water, Power and Labor

The mill tailing is laundered ¾ mile to a small arroyo, where a tailing sand dam now 105 ft. high has been laid down, impounding water for return to the mill when desired. Placement of the sand has been controlled by overhead trestle and Burch de-sanding cones, and building of this dam has not been difficult. The effectiveness of the present flotation methods in rejecting pyrite is forcibly attested by the difficulty in keeping the main tailing launder clear. Here the heavy pyrite rapidly settles and packs, and the addition of much water is necessary to carry it forward.

The chief source of fresh water is the Huacal reservoir, where a concrete single-arch dam, 100 ft. high, stores about 900,000,000 gal. fresh water in the Huacal Canyon at a point sufficiently high to permit gravity flow to the mill-supply tank. The pipe line is 2.91 miles long.

With the present flowsheet, the fresh water consumption averages 700 gal. per ton of ore. In addition, 600 gal. of water returned from the mill sumps and the tailing pond is used, giving a total water consumption of 1,300 gal. per ton. With fresh water obtainable in abundant quantity virtually without cost, no great effort is made to use returned water in preference to fresh, as it has been determined that the reagent content of the returned water does not offset the cost of pumping.

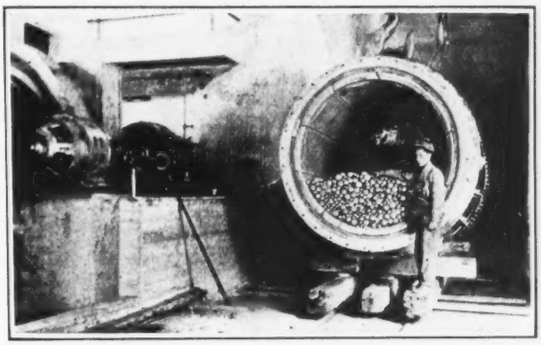
According to the original flowsheet, the total mill power consumption, including coarse crushing, averaged 19.75 kw.-hr. per ton of ore. The all-flotation flowsheet at first raised this average considerably, but it was again gradually lowered until it reached almost the same figure. For April, 1924, it averaged 19.86 kw.-hr., including transmission and transformer losses, and this figure is still being gradually lowered. About 55 per cent of the power is consumed in crushing and grinding, Pilares ores being harder than most others of the Southwest.

Each operating shift consists of seventeen Mexicans, few of whom have ever seen any other mill. Additional employees, including carpenters, repairmen, machinists, electricians and assayers, are also Mexicans. A few supervisory positions, however, including that of shift boss, are filled by experienced Americans. At present, an average of slightly over 18 tons per total man-shift is being milled.

Development of Present Flowsheet

Since the beginning of operations, a gradual improvement has been effected, both in simplification of flowsheet and in bettered metallurgical results, recently culminating in a 28.1 per cent copper concentrate and a 0.2 per cent copper tailing, as a monthly average, with all-flotation at the rate of 1,000 dry tons per unit per day. For shorter periods, a concentrate of 29.5 per cent and a tailing of 0.19 per cent copper have been attained. Experiments are still in progress which, it is hoped, will bring the monthly averages closer to these results, which are now exceptional.

Table II indicates the manner in which the improving metallurgy has been reflected in the results actually obtained in the mill. The improvement in the rejection of the iron, combined as pyrite, and of the "insoluble" constituents is a noteworthy feature of this table. The results have been attained on almost uniform average feed, without permanently impairing appreciably the copper recovery, as can be noted from the tailing assay.



Secondary mill, showing liners and normal rod load

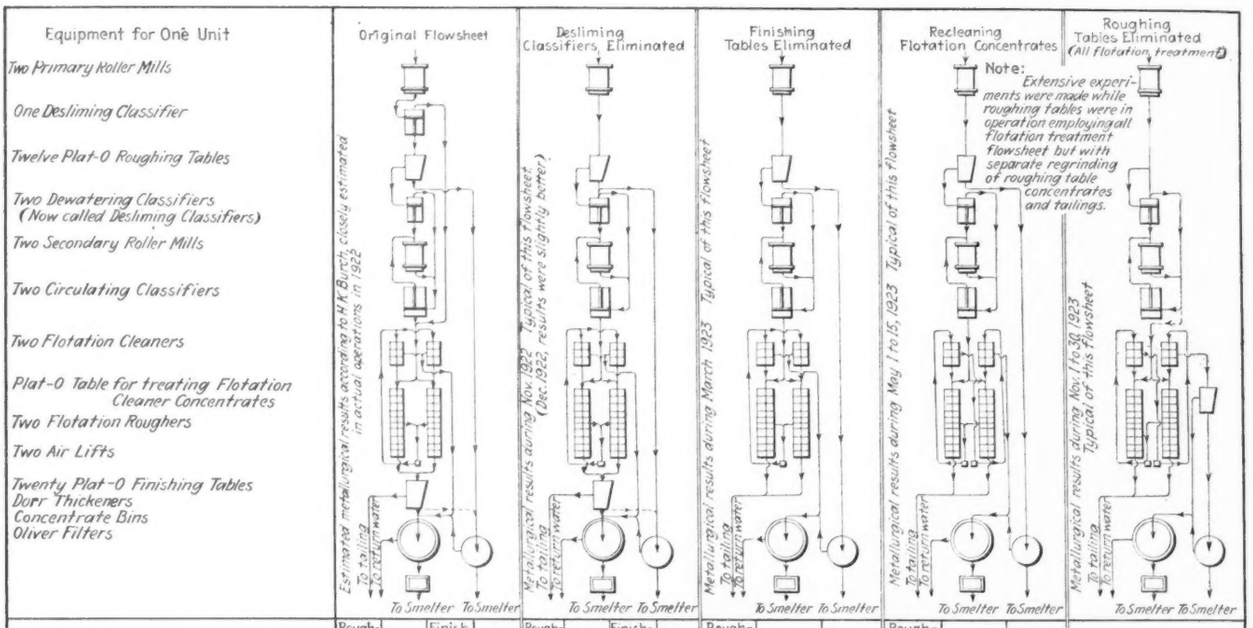
The metallurgical improvement thus far effected has taken place in rather definite steps, which may be enumerated as follows:

1. Desliming classifier removed, June 24, 1922.
2. Alkaline flotation circuit adopted, June 30, 1922.
3. Finishing tables shut down, Jan. 18, 1923.
4. Concentrate double-cleaning system developed early in 1923 and adopted on April 12, 1923.
5. Roughing tables permanently shut down and all-flotation treatment begun on June 1, 1923.
6. Triple and quadruple concentrate cleaning begun during October, 1923, and adopted in January, 1924.

These changes are diagrammed in Fig. 1, with typical metallurgical results. The combined effect of these six steps has been to bring about an all-flotation treatment and additional concentrate cleaning, coincident with improved operating technique, with no permanent decrease in unit-tonnage capacity. Translated into terms

Table I. Screen Analyses of Mill Products, May, 1924

	General Mill Tailing						Flotation Cleaner Concentrate					
	Per Cent by Weight		Cu. Assay		Per Cent Cu. Content		Per Cent by Weight		Cu. Assay		Per Cent Cu. Content	
Mesh	This Mesh	Cumulative	This Mesh	Cumulative	This Mesh	Cumulative	This Mesh	Cumulative	This Mesh	Cumulative	This Mesh	Cumulative
Original			0.21						28.10			
+35	3.10	3.10	0.24	0.24	3.67	3.67	.....	.....	.....	.....	.....	.....
48	10.10	13.20	0.26	0.25	12.96	16.63	.....	.....	.....	.....	.....	.....
65	10.40	23.60	0.30	0.27	15.39	32.02	1.80	1.80	27.22	27.22	1.75	1.75
100	12.40	36.00	0.26	0.27	15.91	47.93	7.20	9.00	28.45	28.20	7.31	9.06
150	7.90	43.90	0.20	0.26	7.79	55.72	9.20	18.20	28.58	28.39	9.38	18.44
200	6.40	50.30	0.16	0.24	5.05	60.77	10.60	28.80	28.30	28.36	10.70	29.14
—200	49.70	100.00	0.16	0.20	39.23	100.00	71.20	100.00	27.90	28.03	70.86	100.00


Equipment for One Unit
Two Primary Roller Mills
One Desliming Classifier
Twelve Plat-O Roughing Tables
Two Dewatering Classifiers (Now called Desliming Classifiers)
Two Secondary Roller Mills
Two Circulating Classifiers
Two Flotation Cleaners
Plat-O Table for treating Flotation Cleaner Concentrates
Two Flotation Roughers
Two Air Lifts
Twenty Plat-O Finishing Tables
Dorr Thickeners
Concentrate Bins
Oliver Filters
Original Flowsheet
Estimated metallurgical results according to H.K. Burch, closely estimated in actual operations in 1922
Desliming Classifiers Eliminated
Metallurgical results during Nov. 1922 Typical of this flowsheet (Dec. 1922, results were slightly better)
Finishing Tables Eliminated
Metallurgical results during March 1923 Typical of this flowsheet
Recleaning Flotation Concentrates
Metallurgical results during May 1 to 15, 1923 Typical of this flowsheet
Roughing Tables Eliminated (All flotation treatment)
Note: Extensive experiments were made while roughing tables were in operation employing all flotation treatment flowsheet but with separate regrinding of roughing table concentrates and tailings.
Metallurgical results during Nov. 1 to 30, 1923 Typical of this flowsheet
To Tailing
To return water
To Smelter

	Original Flowsheet				Desliming Classifiers Eliminated				Finishing Tables Eliminated			Recleaning Flotation Concentrates			Roughing Tables Eliminated (All flotation treatment)
	Roughing Tables	Flotation	Finishing Tables	Total Mill	Roughing Tables	Flotation	Finishing Tables	Total Mill	Roughing Tables	Flotation	Total Mill	Roughing Tables	Flotation	Total Mill	Total Mill
Feed % Copper	*Feed Remained Essentially Constant Throughout*														
Tailing % Copper	1.03	0.28	0.23	0.23	1.78	0.22	0.19	0.19	2.17	0.24	0.24	2.17	0.23	0.23	0.27
Concentrate % Copper	11.00	14.00	3.50	11.95	10.28	17.86	1.75	12.02	10.15	20.27	13.85	9.79	25.78	14.68	26.05
Concentrate % Iron	36.47	25.14	25.54	32.47	35.36	24.12	28.21	31.48	39.23	23.52	33.50	38.25	28.73	35.34	27.53
Concentrate % Insoluble	12.59	27.68	38.48	18.34	11.74	25.86	34.40	17.59	9.90	24.95	15.39	7.93	12.28	9.26	9.58

Fig. 1—Flowsheet changes, 1922-23

of money, which is the ultimate criterion, the results have been gratifying. Indeed, any departure from previous practice has been dictated by the relative financial efficiency of the whole, rather than by the relative mechanical or metallurgical efficiency of any part.

It was soon found inadvisable to use the desliming classifier to handle the primary-mill discharge, because of the relatively coarse material which at times overflowed and caused marked variation in the flotation results, as it was being bypassed direct to the Callow cells. Operation of this classifier was therefore discontinued. The results immediately became more uniform, and improvement in the mill extraction followed. This point was confirmed by subsequent check-test runs of several days' duration; and, as a result, the Construction Department did not include the corresponding classifiers in the second and third units.

Table II. Percentage Distribution of Mineral Combinations

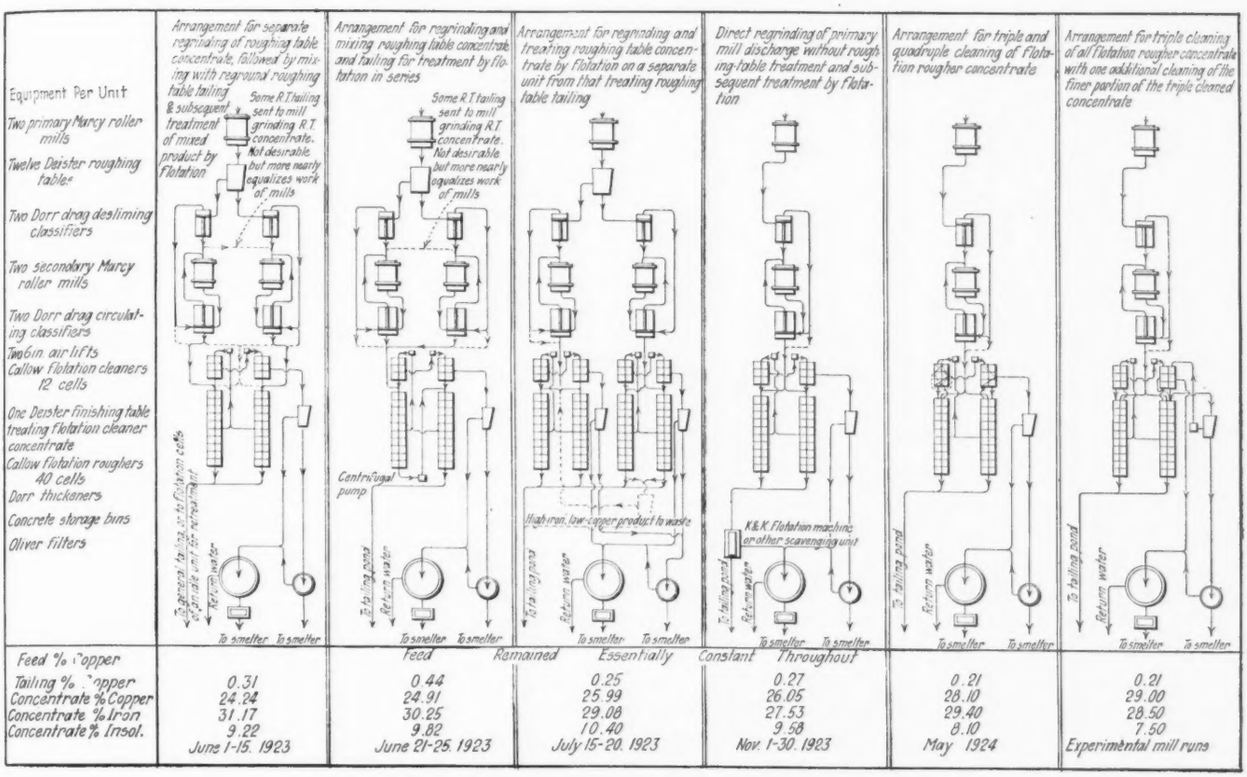
	1922	1923				1924
	7 Operating months,	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	First Quarter
Total copper						
Feed	The feed was essentially constant for all periods.					
Tailing	0.22	0.22	0.28	0.32	0.25	0.24
Concentrate	12.07	13.76	16.50	24.52	25.69	26.67
Total iron as sulphide						
Feed	10.03	10.47	10.60	10.54	9.65	10.53
Tailing	3.83	3.55	4.91	7.73	7.44	8.22
Concentrate	32.47	33.51	34.02	31.08	26.96	27.93
Iron as chalcopyrite						
Feed	Variation slight. Average about 2.5% for all periods.					
Tailing	0.13	0.12	0.18	0.22	0.17	0.16
Concentrate	10.67	12.16	14.59	21.67	22.71	23.58
Iron as pyrite						
Feed	7.30	7.66	7.87	7.82	6.98	7.64
Tailing	2.71	3.43	4.73	7.51	7.27	8.06
Concentrate	21.80	21.35	19.43	9.41	4.25	4.35
"Insoluble"						
Feed	69.67	68.96	68.59	68.39	69.44	66.59
Tailing	86.44	85.44	83.11	76.74	76.56	74.00
Concentrate	18.34	14.64	10.76	7.90	11.89	10.71
Indicated extraction*						
Total copper (fell slightly during last three-quarters of 1923 but is now at former level).						
Total iron	80.76	72.07	57.16	34.42	31.07	31.03
Iron as pyrite	74.49	62.75	43.97	14.05	6.76	6.67
Iron as chalcopyrite (followed closely the slight variation in copper recovery).						
"Insoluble"	6.57	4.78	2.79	1.35	1.90	1.88
Indicated rejection*						
Iron as pyrite	25.51	37.25	56.03	85.95	93.24	93.33
"Insoluble"	93.43	95.22	97.21	98.65	98.10	98.12

*Based on assays of mill heads and of concentrates shipped to smelter.

The addition of lime to the flotation circuit, begun at the end of the first month of operation, was a major improvement. For the six days preceding the change, the mill tailing averaged 0.55 per cent copper, compared with 0.31 per cent copper for the six days immediately following. It may be noted here that lime had been occasionally employed experimentally in the old mill, but apparently without sufficiently improved results to justify its continued use.

By the end of 1922 the flotation metallurgy had been developed to the point where the finishing tables, treating flotation tailing, were unable to show a profit. Freight and smelting charges on the low-grade "concentrate" (1.5 per cent copper), which the finishing tables were then making, exceeded the market value of the copper and the small amount of precious metal present. Economical retreatment of this concentrate was proved impracticable by numerous mill and laboratory experiments. Shutting down the finishing tables decreased the mill extraction at that time by about 1 per cent, a loss which, however, was more than compensated by decreased concentrate transportation and treatment charges.

Double cleaning of flotation concentrate was effected with the existing equipment in April, 1923, by placing one pair of cleaner cells of each unit in series with the other pair, rather than in parallel as formerly. This was done by diverting all of the first rougher froth of any one unit to one air lift, and utilizing the remaining air lift for the second return. For the three months prior to this change the final flotation concentrate averaged 20.55 per cent copper, 24.46 per


Equipment Per Unit
Two primary Marcy roller mills
Twelve Deister roughing tables
Two Dorr drag desliming classifiers
Two secondary Marcy roller mills
Two Dorr drag circulating classifiers
Two 6in. air lifts
Callow flotation cleaners 12 cells
One Deister finishing table treating flotation cleaner concentrate
Callow flotation roughers 40 cells
Dorr thickeners
Concrete storage bins
Oliver filters
Arrangement for separate regrinding of roughing table concentrate, followed by mixing with reground roughing table tailing & subsequent treatment of mixed product by flotation
Some R.T. tailing sent to mill grinding R.T. concentrate. Not desirable, but more nearly equalizes work of mills
To general tailing or to flotation cells of circuit for retreatment
Return water
To tailing pond
To smelter
Arrangement for regrinding and mixing roughing table concentrate and tailing for treatment by flotation in series
Some R.T. tailing sent to mill grinding R.T. concentrate. Not desirable, but more nearly equalizes work of mills
Centrifugal pump
Arrangement for regrinding and treating roughing table concentrate by flotation on a separate unit from that treating roughing table tailing
High iron, low copper product to waste
Direct regrinding of primary mill discharge without roughing-table treatment and subsequent treatment by flotation
K.E.K. Flotation machine or other scavenging unit
Arrangement for triple and quadruple cleaning of flotation rougher concentrate
Arrangement for triple cleaning of all flotation rougher concentrate with one additional cleaning of the finer portion of the triple cleaned concentrate

Feed % Copper		Feed Remained Essentially Constant Throughout				
Tailing % Copper	0.31	0.44	0.25	0.27	0.21	0.21
Concentrate % Copper	24.24	24.91	25.99	26.05	28.10	29.00
Concentrate % Iron	31.17	30.25	29.08	27.53	29.40	28.50
Concentrate % Insol.	9.22	9.82	10.40	9.58	8.10	7.50
	June 1-15. 1923	June 21-25. 1923	July 15-20. 1923	Nov. 1-30. 1923	May 1924	Experimental mill runs

Fig. 2—Mill experiments in all-flotation treatment, 1923-24

cent iron, and 24.15 per cent "insoluble." For the following month these averages were 25.16 per cent copper, 29.97 per cent iron, and 10.17 per cent "insoluble." The introduction of the second stage of cleaning did not cause any noticeable rise in the grade of flotation tailing. The general mill tailing, however, could have risen to 0.51 per cent copper before the improvement shown in the grade of concentrate would have failed to effect a financial saving. During October and November, 1923, the best results with double cleaning were attained, when an average flotation concentrate of 26.04 per cent copper, 26.81 per cent iron, and 11.35 per cent "insoluble" was maintained; and, furthermore, this was then the general mill concentrate, because the all-flotation treatment had also been developed in the meantime. The double cleaning continued in use until the third and fourth stages, described later, were added.

With the grade of flotation concentrate brought to what then appeared to be the maximum feasible, and with the discontinuance of production of the low-grade finishing-table concentrate, two possibilities existed for establishing parity between the grade of the concentrates produced by the roughing tables and by flotation: (1) Separate retreatment of the roughing-table concentrate, to raise the copper grade, or (2) the elimination of the roughing-table process and the substitution of all-flotation. After much experimenting with both methods, the second plan was adopted and is now in use. Tests had been conducted with all of the roughing tables out of service on several previous occasions, notably on July 26 and 27, 1922, less than two months after the new mill commenced operation, and again on April 27 and 28, 1923, as well as during several shorter periods. Although results of even the earliest of these tests were promising, the shutting down of the roughing tables was then considered untimely, and it was deemed advisable first to devote full attention to improvement of the metallurgy of the flotation department.

The experimental work involving each of the two above-mentioned methods and leading to the present all-flotation flowsheet is sketched in the following paragraphs.

Separate Retreatment of Roughing-Table Concentrate

The roughing-table concentrate usually averaged about 10 per cent copper, 40 per cent iron, and 10 per cent "insoluble." This seemed an advantageous point at which to isolate the pyrite. To this end, finer grinding of the mineral appeared to be a prime requisite, because mechanical breaking down of the intimate mixture of chalcopyrite and pyrite is the fundamental premise of their separation. In the treatment of any ore the limit of selective flotation is fixed by the degree of mechanical liberation of the contained individual minerals.

That the reground roughing-table tailing was sufficiently fine was indicated by the fact that frequent microscopic examination of the various mill products showed that a reasonably complete mechanical liberation of the chalcopyrite, pyrite, and "insoluble" constituents in what was then the flotation feed was being effected. Study and interpretation of the effect of various changes in flotation operation, notably recleaning, substantiated this conclusion.

To investigate the possibilities of separate retreatment of concentrate, launders were put in to conduct the roughing-table concentrate of the two operating units to the then idle third unit, where it was reground in the secondary mills and subsequently floated in the

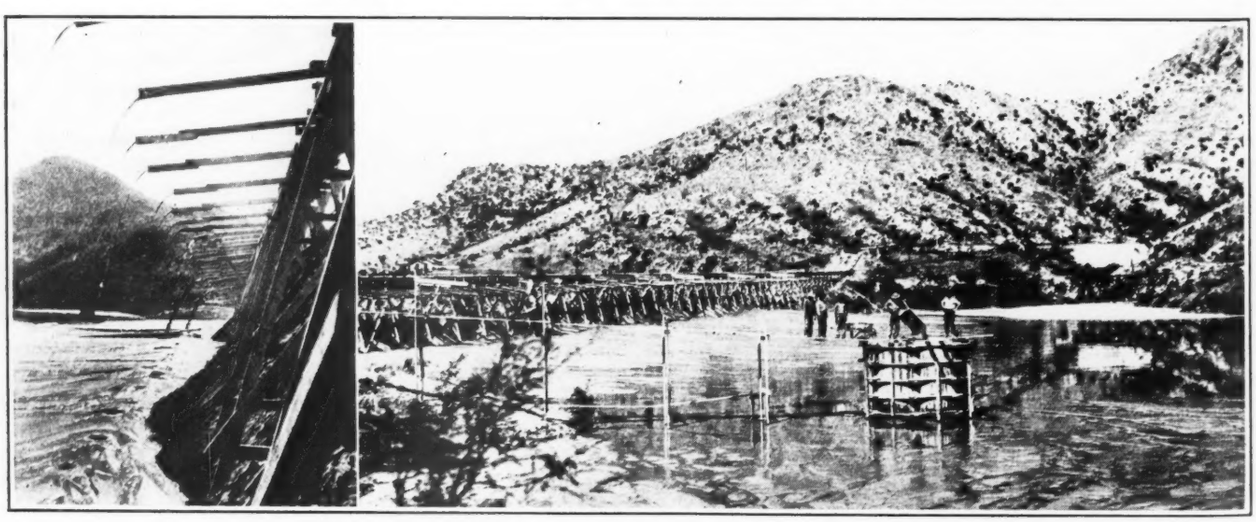
Callow machines of that unit. Both primary mills of this third unit remained idle. This procedure was followed intermittently during May, June, and July, 1923, the best results being averaged during the period July 15 to 20, when the retreatment unit stepped up a roughing-table concentrate—purposely drawn low grade and averaging 7.1 per cent copper, 30.8 per cent iron, and 27.6 per cent "insoluble"—to 27.8 per cent copper, 32.1 per cent iron, and 4.8 per cent "insoluble." The combined general mill concentrate during this period averaged 26.0 per cent copper, 29.1 per cent iron, and 10.4 per cent "insoluble." The total combined general mill tailing averaged 0.25 per cent copper. The flotation tailing of the retreatment unit averaged 0.61 per cent copper, 30.3 per cent iron, and 35.2 per cent "insoluble"; this was treated on several of the finishing tables of the same unit, but a satisfactory concentrate could not be made, and both the concentrate and tailing went to waste. The concentrate was low in copper but usually averaged 40 to 45 per cent iron. It is possible that at some time in the future such a concentrate would have value for its iron or sulphur content.

Existing conditions were such that continued use of this flowsheet was impracticable. The Callow cells, as installed with a slope of only ¼ in. to 1 ft., were not well adapted for the new demands made upon them. Rejected pyrite, which settled and packed on the canvas bottoms, impeded aëration and seriously hampered operation. The requisitioning of the third unit was justified only as an experiment to prove the theory of the method, with full cognizance of the fact that the individual mill units, for practical operation, should be self-contained. Nevertheless, the production and separate retreatment of a high-iron roughing concentrate is, in my opinion, sound in principle if a separation of chalcopyrite and pyrite is to be effected, particularly where roughing tables are already provided.

To make each unit self-contained, another method of separate retreatment was tried. For a time, effort was made to grind all of the roughing-table tailing in one secondary mill, the roughing-table concentrate being separately reground much finer in the other. The tonnage to the mill that was grinding tailing was found to be so great that it was necessary to divert a portion to the mill that was grinding concentrate. So much was finally diverted that there ceased to be any advantage in keeping the two products separate. The tables were accordingly bypassed, and have not been used since June 1, 1923, except for brief experimental intervals. Reversion to all-flotation was thus brought about automatically. Arrangements for both methods are shown in Fig. 2 (see page 449).

The All-Flotation Flowsheet

The primary-mill discharge of each unit bypasses the roughing tables and after classification is reground in the secondary mills, which still operate in parallel in closed circuit with drag classifiers. The finished product of the secondary mills, the circulating classifier overflow, is evenly divided between the four rows of flotation rougher cells, the tailing from which is general mill tailing. The flotation concentrate, after recleaning, is laundered to two of the former finishing tables for further treatment. This latter practice was begun in February, 1923. The tables not only serve as excellent froth breakers and simplify subsequent thickening operations, but also remove about 40 per cent by weight of the mineral, consisting of the coarser, higher-grade portion, which is then sent directly to the storage bins formerly handling the roughing-table concentrate. These bins have porous bottoms, connected by manifold to a Nash vacuum pump. Here the coarse material is readily settled and dewatered by decantation and draining to about 7 per cent moisture, for shipment to the smelter. According to smelter returns, it has ranged between 27 and 30 per cent copper for the last eight months. The coarser mineral thus removed had formerly caused much damage to the filter agitators by settling in the hoppers. The finer portion of the flotation concentrate, overflowing the tailing side of the tables, constitutes about 60 per cent of the total mill production of concentrate; it is laundered to one 60-ft. Dorr tank for thickening, except when pumped back to the flotation cleaner cells for additional separate re-cleaning, to be described later. The thickener discharge, averaging about 60 per cent solids, is reduced by one 14x14-ft. Oliver filter to about 13 per cent moisture. Gravity-bin overflow water, filtrate and other miscellaneous water collecting at the filter-plant sump is returned to the one 60-ft. tank also, for clarification.



At left, overflow launders from cones at tailing dam. At right, pouring an addition to concrete overflow chimney at the tailing dam

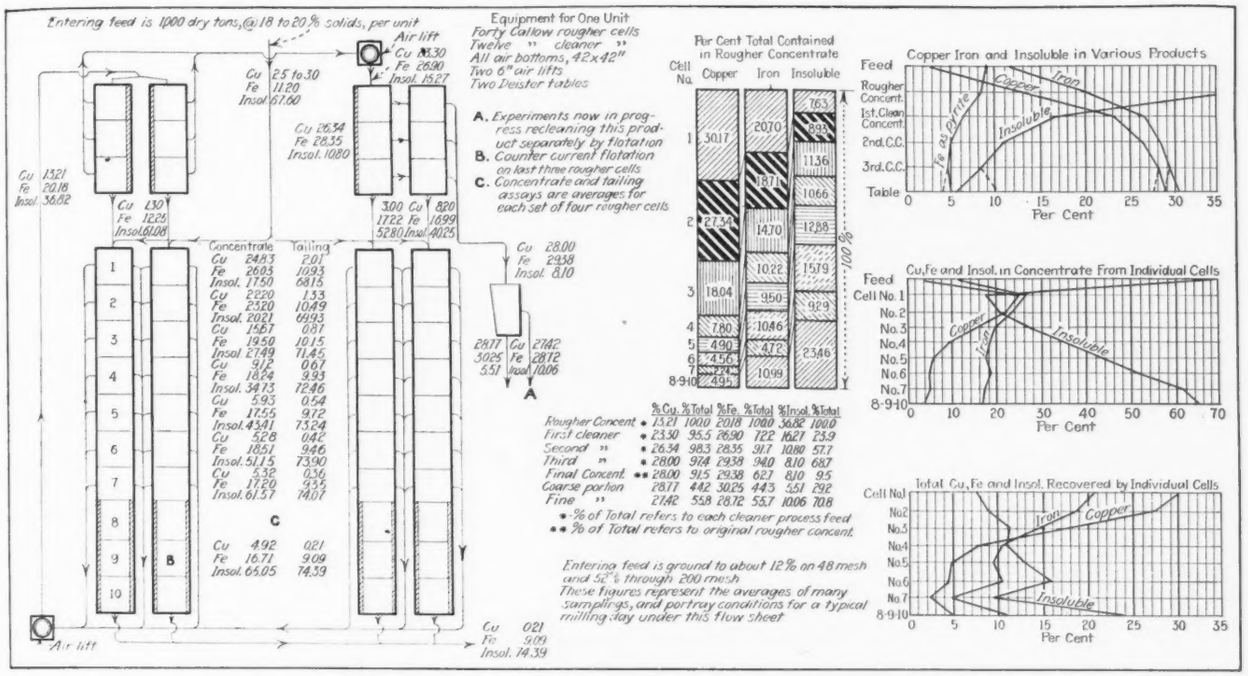


Fig. 3—Flowsheet and assay chart of flotation operations

The clear overflow from this is returned to the head of the mill by an Aldrich triplex pump.

It is significant that ordinarily only one thickener and one filter have been in use at any one time during the past six months, even with three units operating at capacity. Largely by virtue of the improved all-flotation treatment, several other tanks and filters provided by the Construction Department are now idle.

Triple and Quadruple Concentrate Cleaning

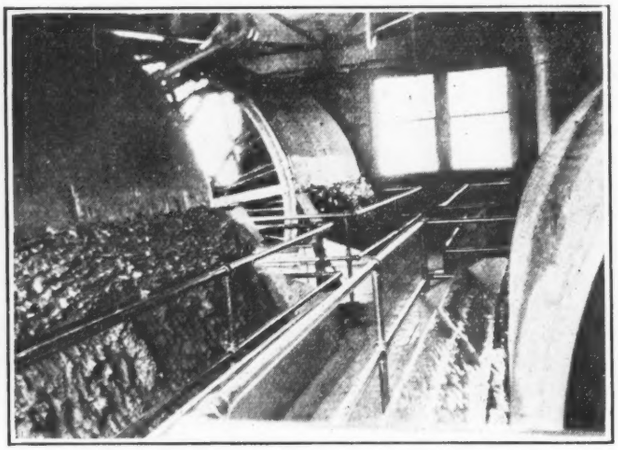
With four rows of cleaner cells available, the limit of series treatment is four steps. In the original design, the four rows were in parallel. As already described, two rows were subsequently placed in series with the remaining two rows, to effect double cleaning. For triple cleaning, two rows were put in series and the concentrate was then passed by air lift to the remaining two rows, which were left in parallel. For quadruple cleaning, all four rows were placed strictly in series, all of the rougher froth of any unit entering the first row and thence passing consecutively through all to the fourth. A unit so arranged will deliver a final concentrate assaying 29.0 per cent copper, 28.5 per cent iron, and 8 per cent "insoluble." Triple cleaning is now in effect, pending the completion of other experiments. The mechanical arrangements necessary to accomplish this departure from the pulp flow provided in the original equipment required some improvising. These flowsheets are included in the panels of Fig. 2 (see page 449).

An additional method of concentrate cleaning has proved successful at Nacozari. With double cleaning only, the slimy "tailing" side overflow of the Deister tables handling flotation concentrate contained much quasi-colloidal alumina and silica and was about 6 per cent lower in copper than the coarse product of the tables. For some time this material was pumped back to the fourth row only of the cleaner cells for an additional stage of separate cleaning. The "insoluble" content was thus reduced materially, and the unit concentrate was improved in grade from about 26.0 per cent copper, 27.0 per cent iron, and 13.0 per cent "insoluble," to 29.0 per cent copper, 27.5 per cent iron, and 8.5 per cent "insoluble." With triple and quadruple cleaning, this difference between the table products was lessened materially, although experiments with separate recleaning of the table "tailing" have given improved results and are still in progress. This method makes possible the robbing of the system of a relatively coarse, high-grade product at an intermediate stage prior to the final cleaning. The last cleaner cells are thus relieved of much coarse mineral. Furthermore, the removal of alumina and silica by any process of cleaning greatly aids filtering; a granular filter cake containing 10 to 12 per cent moisture is obtained when the amount of these constituents is reduced to a minimum.

The rôle of additional stages of concentrate cleaning in selective flotation may be summarized in terms of Nacozari experience as follows: The selection by flotation of one mineral in particular from several is a function of time and of opportunity. The individual minerals are recovered in the progressive order of their amenability to the flotation treatment given. With crowded cleaner cells and rapid elimination of cleaner tailing, only those particles overflow as concentrate that are most readily floatable. The remainder, though possibly returning to the cleaner cells a number of times, as part of the circulating load, are unable there to overflow as concentrate because of the continuous fresh influx of the preferred mineral with the feed, and are ultimately rejected with the mill tailing when the circulating load has built up to equilibrium and is no longer able to sustain them.

Repeated assaying of products at intermediate stages of the flotation treatment, and showing individual cell performances, has afforded interesting information, of which profitable advantage has been taken. Fig. 3 is a chart giving detailed typical average results obtained throughout the flotation cycle.

Microscopic examination and chemical analysis of the concentrate overflowing from the individual rougher cells afford snapshots that reveal a progressive action. Such study at Nacozari has shown that the ratio of iron to copper in the concentrate nearer the tailing end is much higher than toward the feed end, with chalcopyrite recovery preceding that of the more sluggish pyrite, and with a hybrid zone between if grinding has been insufficient to effect complete mechanical liberation of the various constituent minerals. It is



Oliver filters and concentrate discharge

possible that a regrinding of the concentrate that overflows some of the individual rougher cells would prove profitable.

Countercurrent Froth Removal

In the flotation of any ore, it is obvious that the grade of the original feed establishes an empirical minimum which the grade of the rougher froth from any individual cell should exceed, in order to justify its progression to the cleaner cells rather than its regression to join the entering feed. With that arbitrary standard set up, countercurrent froth removal has been introduced on all of the rougher machines. Although the froth overflow of the last several cells of each row of roughers assayed lower in copper than the flotation feed, it was being sent to the cleaner cells because existing arrangements of equipment were such that the direct return of this lean froth to the rougher feed was impracticable. By the countercurrent method, this froth has been doubled in grade and reduced in volume without increase in tailing loss. In lieu of a direct complete return, the overflow sides of the three lower cells of each rougher row have been boarded up, and cross baffles of graduated height put in, extending down slightly below the pulp level. The height of the froth column is thereby increased by about 6 in. and the froth is forced to flow back toward the head of the machine, being cleaned en route and escaping with the concentrate of the fourth cell from the tailing end. The pulp below the froth continues to flow normally. Possible variations in the application of this principle are numerous and are not limited to one continuous machine.

A possible further advantage of the countercurrent method of froth removal lies in the fact that a greater volume of air may be applied to the modified cells without sloughing of low grade tailing pulp over the sides of the machine. This greater air volume assists in floating mineral which might not have been lifted otherwise. Further experimental work with the method is being done.

Series treatment as applied directly to the flotation feed, which then consisted of reground roughing-table tailing only, was investigated early in 1923, by directing all of the feed to two rows only of rougher machines and pumping the tailing back to the two remaining rougher rows of the same unit. No beneficial results were obtained. At times, the entire unit flotation tailing from all four rows of flotation machines regularly operating in parallel has been pumped to the flotation machines of a temporarily idle unit and there subjected to a retreatment. A lower final tailing always resulted, but the indicated saving has never been sufficient to demonstrate conclusively a satisfactory margin over the cost of pumping, or to justify the expense of constructing additional cells at the lower end of the present roughers.

The air pressure to the flotation machines is maintained between 5 and 6 lb. per square inch by one No. 7 Roots blower per operating unit.

A complete chemical analysis and an elemental balance, including also a mineral compound balance, of mill feed, tailing, and concentrate, are made each month. These analyses indicate the recovery or rejection of individual elements and mineral compounds in a way that can be very useful in the refinement of milling practice. Although considerable information of value has been gained, a discussion of this phase would necessarily take up more space than is available here. However, the analyses of general mill tailing and general mill concentrate for May, 1924, are given in Table III to illustrate the starting point from which the elemental and compound balances are developed.

Table III. Analysis of General Mill Tailing and Concentrate, May, 1924

	General Mill Tailing Per Cent	Flotation Cleaner Concentrate Per Cent
Cu, total	0.21	28.08
Cu, sulphide	0.15	27.96
Fe	10.24	29.42
Zn	0.49	0.60
S	6.30	33.74
CaO	2.10	0.46
Al_2O_3	16.30	1.97
SiO_2	54.00	4.84
MgO	1.99	0.22
Remainder, including Na and K	8.37	0.67

Recovery of the small amounts of gold and silver contained in the ore has varied directly with that of the copper and has not been lowered appreciably by the change to all-flotation treatment.

New Flotation Agents Give Good Results

Until Dec. 1, 1923, coal tar and pine oil—and, for a time, creosote—were regularly used as flotation agents. When operation was begun in June, 1922, on the combined gravity-flotation flowsheet, about 3.6 lb. of total oils were at first used per dry ton of flotation feed, made up of gas-works coal tar, Barrett No. 6 creosote, and steam-distilled pine oil. The creosote was later discontinued with no detrimental effect upon the tailing and with a marked decrease in the amount of froth in the Dorr thickeners, which simplified tank operation. The consumption of coal tar and pine oil was gradually decreased until in October and November, 1923, when the best results with the oils were attained; the consumption per ton of mill feed on the all-flotation flowsheet was reduced to 0.35 lb. of total

oils. It should be borne in mind that the shutting down of the roughing tables had practically doubled the total amount of sulphide minerals in the flotation feed. Our experience indicates that a minimum rate of oil supply is essential to selective flotation between chalcopyrite and pyrite, explainable by the possibility that, under existing conditions, the oil is first appropriated by the chalcopyrite, leaving little to serve the pyrite.

Other oils investigated in mill-test runs included crude petroleum, "PE" oil, and Scotch blast-furnace oil; and a large number of the flotation oils on the market have been tried in the laboratory test machines. None equaled in effectiveness the regular coal-tar and pine-oil mixture, although the results with the blast-furnace oil closely approximated those regularly obtained. Any discussion of the relative merits of various agents, of course, limits itself to the particular ore upon which all have been tried.

In September, 1922, the General Engineering Co. made laboratory experiments on Pilares ores, using various special flotation agents of the Metals Recovery Co. Promising results were obtained with thiocarbanilid (diphenylthiourea) and orthotoluidin, which are ordinarily employed as the "T/T mixture" consisting of 20 per cent thiocarbanilid dissolved in 80 per cent orthotoluidin. A short mill test with these agents was made at Nacozari on Jan. 22, 1923, followed by large-scale mill runs during three weeks of August and all of December, 1923. The August tests were supervised by C. L. Perkins, of the Metals Recovery Co. The regular oils were again used during January, 1924, but the T/T mixture was reverted to on Feb. 1, 1924, and has been employed constantly since. Both the T/T mixture and the required pine oil are introduced by locally designed pulley feeders, each equipped with several flattened-wire take-offs, into the circulating-classifier overflow, and do not pass through any of the mills. Most of the coal tar, used previously, was added to the primary-mill feed.

A slightly lower average tailing has been obtained with these chemicals than with the oils. A larger percentage of the mineral is removed near the feed end of the rougher cells, thus allowing more time for scavenging action toward the tailing end. This feature favors the satisfactory handling of somewhat larger tonnages. The consumption of the T/T mixture averages 0.28 lb. per ton of ore, with which 0.14 lb. of steam-distilled pine oil is also added. The orthotoluidin does not exhibit marked flotative properties and serves chiefly as a vehicle for the thiocarbanilid. Experiments are now under way purposing to decrease the proportion of orthotoluidin necessary. Local tests using undissolved, dry thiocarbanilid have not been successful so far. The use of colloidal thiocarbanilid is an interesting possibility, because the properties of a colloidal solution approach those of a true solution as molecular dispersion is approached. Further knowledge of chemical flotation agents may permit the elimination of any inert intermediate solvent. Recent laboratory tests using the new Q.E.D. flotation agent (water soluble), of the Metals Recovery Co., have proved promising, and additional tests will be made.

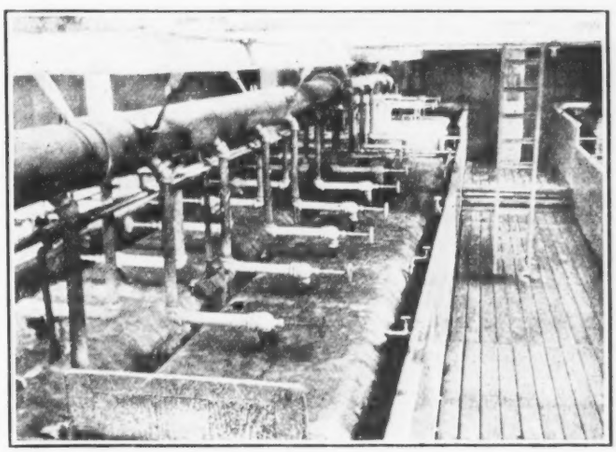
The higher grade of concentrate recently obtained is explained by the additional concentrate cleaning now practiced, and is not traceable to the change in flotation agents. For two months preceding this change, a general concentrate of slightly over 26 per cent copper was averaged with only double cleaning. This indicates that the selectivity of flotation at Nacozari, in an alkaline circuit, has been independent of the type of flotation agent used, comparing oils and chemicals.

The degree and control of pulp alkalinity has been found to be most important. Burned lime is used, the cheapest base available in large quantities. Soda ash was tried for a time with inferior results. Sodium silicate and other alkalies did not give promising results when tried in the laboratory.

Function of Lime in Flotation

Dry lime is fed mechanically onto the ore conveyors leading from the fine-ore bins to the primary mills. Burettes are provided, and the Mexican operators make frequent titrations. An investigation has been under way at Nacozari for nearly one year, to ascertain if the alkalinity of the mill solutions could be determined by measurement of their electrical conductivity by means of the Wheatstone bridge. It has been found that this value is a direct index of the dissolved lime content in the mill circuits, and is not subject to sufficient interference by other dissolved salts, suspended solids, or temperature changes to render the determination impracticable. The instrument used at present requires manual setting, but it is anticipated that an automatic and continuous indicating dial will be applied, with possibly a recording device also.

Best flotation results are obtained when the tailing pulp shows a lime content equivalent to 0.15 to 0.35 lb. of calcium oxide per ton of clear solution, depending somewhat upon the quality of the lime used. When the alkalinity falls below this minimum, high flotation tailing usually ensues, whereas an unduly high alkalinity changes the character of the froth unfavorably and involves a waste of reagent.



Callow flotation cells from tailing end

When a good quality of lime is available, the consumption averages from 5 to 6 lb. per ton of flotation feed. For a time, when the T/T mixture was first used, 7 or 8 lb. of lime per ton was considered necessary, but recently the consumption has been reduced.

The functions of lime in flotation include the neutralization of natural acids, precipitation of possibly detrimental soluble salts, prevention of oxidation of the sulphides, coagulation and deflocculation, and modification of the physical properties of the electrolyte.

As typical of the work being done at the Nacozari concentrator, at the date of writing (June 4, 1924), the metallurgical results obtained in May, 1924, are here given:

Feed. Normal-grade copper (0.07 per cent acid-soluble); 12.2 per cent iron, (67.5 per cent insoluble).

Tailing. 0.205 per cent total copper (0.06 per cent acid-soluble); 10.3 per cent iron, (74.3 per cent insoluble).

Concentrate. 28.1 per cent total copper, 29.4 per cent iron, 8.1 per cent "insoluble."

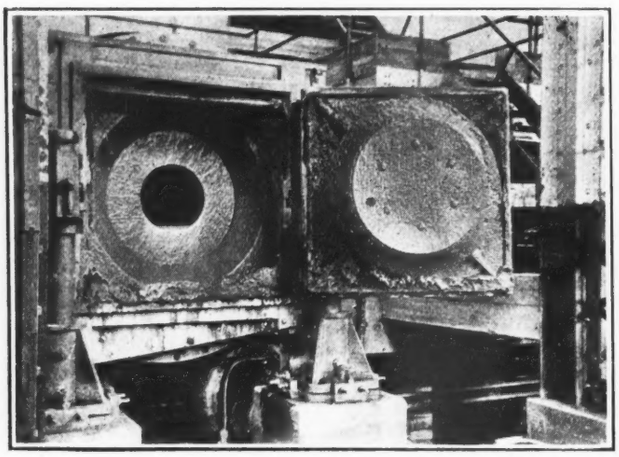
Indicated rejection. 90.0 per cent iron, as pyrite; 98.5 per cent "insoluble".[2]

Briefly recapitulated, the benefits accruing from the metallurgical improvements described are:

1. The use of the following equipment has been discontinued and the expense of operation and maintenance has been avoided: (a) all roughing tables; (b) all finishing tables, except one per unit, which has been adapted to the handling of flotation concentrate; (c) all but one of the Dorr thickeners; (d) all but one of the Oliver filters.

2. Comparing the average metallurgical results for the seven operating months of 1922 with those of May, 1924, the grade of total mill concentrate has been raised from 12.1 to 28.1 per cent copper; the ratio of concentration has been multiplied by 2.4; the rejection of iron, combined as pyrite, has been increased from 25.5 to 90.0 per cent; and the rejection of "insoluble" has been increased from 93.4 to 98.5 per cent. Neither the grade of mill tailing, the per-ton power consumption, nor the unit tonnage capacity has been affected adversely.

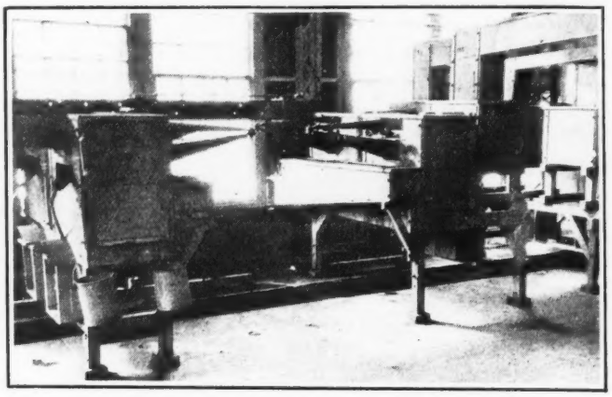
3. A comparison of the best metallurgical results of the original flowsheet, as typified by the last quarter



Opening (18 in.) at discharge end of secondary mill

of 1922, with the most recent average monthly results under the present flowsheet, and handling ore of the same grade and character, reveals that for each 1,000 tons of ore milled, the weight of concentrate shipped to the smelter has been decreased by 145 tons, yet containing the same weight of total copper. This 145 tons, diverted from the concentrate to the tailing, consisted of 105 tons of pyrite almost barren of copper and 40 tons of siliceous gangue.

4. After thorough consideration of all items affecting costs and profits, including both those making for greater saving and those tending to increase expenses and losses at various points, it may be stated definitely that the average net financial saving throughout the past year has been increased by somewhat over 50c. per ton of ore treated, as a result of these improvements. On a basis of 60,000 tons milled monthly, this means a net increase in saving of over $30,000 per month. As already emphasized, any departure from previous practice has been governed by financial consideration of the ultimate whole, rather than by the relative mechanical or metallurgical efficiency of any part, the purpose at all times being that relative financial efficiency should be the barometer of operation.



Automatic samplers in Nacozari mill

Improvements made in metallurgical and operating practice, as herein outlined, have been made much easier of accomplishment by the most progressive and liberal attitude of H. T. Hamilton, who for five years was manager for the Moctezuma Copper Co., and that of Frank Ayer, general superintendent, who succeeded to the management on Jan. 1, 1924, after the resignation of Mr. Hamilton. E. H. Rose and R. R. Beard, of the concentrator staff, have greatly assisted me in the preparation of the text and the accompanying data of this paper.

[2]The grade of concentrate has continued to improve. For June, 1924, the average concentrate assayed 28.6 per cent copper; for July, 1924, 29.1 per cent copper.

Production of Mica in Madagascar

Since 1918 the mica deposits of the French island of Madagascar have been undergoing exploitation. Practically on top-surface, these valuable deposits had hitherto been neglected. The industry came into being within two months of the time of granting the concessions. France is no longer contributory to Canada, the Indies, or Russia, or at least might be free, as the Madagascar deposits are of a sufficience and a quality to provide for all French needs.

The deposits are readily accessible in the districts of Ambatofotsikely (Girod mine), north of Lake Alaotra (Jules Kraft mine), in the province of Fianarantsoa (Guage mine), at Anjanabonina (Rossi mine), and various other points, notably in the provinces of Fort Dauphin and Betroka, where the exploitations are in the hands of the Compagnie Louys et Bornand. Recently new deposits have been discovered and are about to be opened by the Garifalos company in the Kandreho province. These deposits are distributed over an area half as large as that of France, and it is obvious that prospecting was undertaken seriously and equally obvious that the industry is one of a rapidity of growth and importance which is unusual.

The Return to Normal of the Copper Industry

Study of Producers' Records Shows How Reserves, Depreciation, Depletion and Other Auditing Factors Are Handled—Present and Pre-war Conditions Compared—Price Not Likely to Pass 15c. Level for Some Time

By Arthur Notman
Consulting Mining Engineer and Geologist, New York

THE MOST IMPORTANT question before the copper producer is to know what he has to face in the future. In attempting to answer this, one naturally turns to the history of the industry. So far as the recent past is concerned, the results attained in 1921 and 1922 were so universally out of line on account of the cessation of production in the face of very large accumulations of unsold copper and little demand, that their study reveals nothing about the present level of prosperity of the business. In 1923, however, the efforts of all operators were centered on bringing their organizations to the highest pitch of efficiency. Therefore, 1923 results may be regarded as fairly representative, and comparison with those attained in the more remote past will indicate how far they are from normal.

"EVERYBODY is waiting for the other fellow to do the curtailing, because to do so inevitably means higher costs. The law of supply and demand works inexorably, and those unfortunate and misguided ones who expect aid from their more successful rivals will appeal in vain. Their one hope of raising themselves from the ignominious position of 'marginal producers' to that of active competitors, lies in equipping themselves with the very latest 1924 model, throwing out all unnecessary weight, stepping on the gas, and giving the other fellows their dust."

Specifically, the points to be studied to fix the present level of prosperity of the copper business may be enumerated as follows:

1. The amount of present (1923) earnings available for dividends.
2. The probable continuity and range of future earnings.
3. The proper allocation of returns (a) to amortization of capital with interest, and (b) to profits.
4. The nature and function of working capital, the amount required and its relation to the above factors.

An accurate measure of the resultant of these forces would give the present worth of the business. Needless to say, any such measurement, no matter how accurate, will locate but one point on the curve of prosperity, and of itself furnish no proof of where tomorrow may find it. Here the history of the business gives the necessary clew to plot the points of the curve over which we have passed, and enables one to extrapolate those ahead.

Past Performances a Guide

The first point is readily measured within reasonable limits of error, and by comparison with past performances, the foundation from which to gage the level can be laid. The second involves detailed study of the tonnage and grade of reserves of ore yet to be mined and treated, as well as the probable receipts from the sales of the product. Though history will again aid directly in estimating the latter factor, nothing short of individual examination of each property would bring the correct answer to the former. Even here, however, history may play a major part in disclosing the probable future life of the deposits. It is beyond the limits of the present investigation to attempt such a study, which might well constitute the work of a lifetime.

Still, as shall be made evident, ready-made estimates are available which furnish sufficiently accurate bases for relative valuations. The third point depends directly on the second and is ascertainable therefrom. But within the limits ascribed above, it can only be arrived at in a somewhat arbitrary manner. The fourth and final point, though seemingly a minor factor, bears a peculiar and important relation to the undertaking of converting copper ore in the ground into cash in the pockets of the owners. It performs a function similar to the physico-chemical reaction of a catalytic agent in the transformation of matter, or that of the electrolyte in electrolysis. With diminishing volume and exhaustion of the agent the transformation is retarded and ceases. No matter how potentially valuable the transformation may be, it cannot take place except in the presence of the agent, and the reaction rate varies directly with the strength and volume of the latter present. So with the conversion of copper ore in the ground into cash in the pocket, it cannot take place except in the presence of working capital, and the rate of conversion will vary directly with the quality and quantity of working capital present.

It seems logical to expect that the strain of the war demand followed by the catastrophic post-war deflation should be reflected differently by the present condition of the various units of the industry, even though the average in 1923 may differ in only slight degree from pre-war figures.

In Table I will be found a comparison of the production, and total and per pound earnings available for dividends in 1923, of a representative group of copper companies; that is, the earnings after all charges, including interest, taxes and depreciation, have been met and all miscellaneous income credited, but before any provision for amortization of capital with interest (depletion) has been made. As will be evident later, through failure to apprehend the significance and importance of the cost of depreciation, it is improbable that all these earnings could actually be distributed as dividends to the stockholders.

Table II shows a comparison of these results per

pound with those obtained by the same group of companies in the pre-war period, 1911 to 1915 inclusive, and in the war and post-war boom period, 1916 to 1920 inclusive, as measured by the dividends paid per pound produced in those periods. In both these tables, the companies are listed in the order of their performances per pound produced.

Table I—Production, Total Earnings, and Earnings per Pound Available for Dividends, of Copper Companies for 1923

Company	Production, Pounds	Earnings Available for Dividends Total	C. per Lb
Cerro de Pasco	92,176,000	$6,700,169	7.27
Chile Copper	204,897,590	12,910,627	6.30
Utah Copper	195,142,919	10,472,793	5.37
Kennecott (Alaska)	50,945,719	2,705,401 est.	5.31
Miami Copper	64,611,145	2,301,386	3.56
Braden Copper	139,530,000	4,932,805	3.54
New Cornelia	38,267,718	1,309,327	3.41
Nevada Consolidated	61,573,246	2,094,678	3.40
Inspiration Consolidated	88,881,012	2,084,012	2.35
Anaconda Copper (Butte)	215,107,226	4,302,145 est.	2.00
Calumet & Arizona (Excluding New Cornelia)	42,324,038	804,599	1.90
Sub-total	1,206,280,613	$50,617,947	4.20
Ray Consolidated	61,385,205	1,036,523	1.77
Old Dominion	26,764,801	255,304	0.95
Chino Copper	54,261,228	194,613	0.36
Greene Cananea	41,991,369	−255,932	−0.37
Grand total	1,377,859,216	$52,360,319	3.80

Table II—Comparison of Dividends

Company	Dividends Paid per Pound, 1911-1915	Company	Dividends Paid per Pound, 1916-1920	Company	Earnings per Pound Available for Dividends, 1923(*b*)
	c.		c.		c.
1 Nevada	5.10	1 Utah (*a*)	8.79	1 Cerro de Pasco	7.27
2 Cal. & Ariz.	4.66	2 Inspiration	8.53	2 Chile	6.30
3 Old Dominion	4.00	3 Cal. & Ariz.	8.36	3 Utah (*a*))	5.37
4 Anaconda (*a*)	3.89	4 Nevada	7.84	4 Miami	3.56
5 Miami	3.46	5 Chino	7.46	5 Braden	3.54
6 Chino	3.38	6 Miami	7.16	6 New Cornelia	3.41
7 Utah (*a*)	3.25	7 Ray	6.15	7 Nevada	3.40
8 Ray	2.09	8 Anaconda (*a*)	5.77	8 Inspiration	2.35
9 Greene Can.	1.99	9 Greene Can.	5.73	9 Anaconda (*a*) est	2.00
10 Cerro	(*c*)	10 Cerro	5.71	10 Cal. & Ariz.	1.90
11 Braden	none	11 Old Dominion	4.79	11 Ray	1.77
12 Chile	none	12 New Cornelia	0.92	12 Old Dominion	0.95
13 Inspiration	n.p.	13 Chile	none	13 Chino	0.36
14 New Cornelia	n.p.	14 Braden	none	14 Greene Can.	−0.37
Averages	3.67c.		5.99c.		3.74c.

(*a*) Companies have received dividends from other companies in the group considered, which have been deducted from the total of their distributions.

(*b*) The same method has been followed in the matter of earnings in 1923. In the case of Anaconda, the estimated figures apply to all their operations excepting those of the American Brass Co. and Chile Copper Co. and are based on the copper output of their Butte operations, but include all earnings excepting those cited above.

(*c*) Cerro de Pasco's dividends for the first period are not available, so that in arriving at the average, their production has been omitted.

Summary of Table II

Period	Production Pounds	Per Cent of World's Total	Dividends	Per Cent of Price Received
1911-15	3,276,904,491	31	$120,264,408	23.9
1916-20	5,414,113,132	40	324,362,126	25.6
			Earnings Available for Dividends	
1923	1,326,913,497	46	$49,654,918	26.0

Note. Taking the first 1,117,821,560 lb. or 39 per cent of the world's total produced by this group of companies in 1923, it is found that they earned, available for dividends, $48,892,628 or 30.3 per cent of the price received. Assuming that actually 70 per cent of these reported earnings might have been safely distributed, we have a figure of 21.2 per cent of the price received, or 3.06c. per lb. compared with 3.67c. per lb. distributed in the pre-war period, and a normal figure of about 4c. per lb. for the industry as a whole.

The story would be incomplete without a consideration of the capital or depletion cost per pound to be deducted from these earnings, before any real profit above the return of capital with interest will be realized. In attempting to estimate this cost, I have arbitrarily assumed that the invested capital should be returned with interest at 5 per cent in twenty years. This will demand annual installments of 8 per cent of the principal amount. The present value of $1 to be paid back in twenty, thirty or forty years is only 38, 31 and 26 cents respectively. Beyond fifty years the amount is so small as to be insignificant. Of course many of the group have ample reserves of ore to insure a much longer life, and some undoubtedly have insufficient reserves to warrant postponing the return of capital even for twenty years. The history of the business has shown that fundamental changes have taken place in the past in even shorter periods, resulting in such substantial realignment of competition that some of the leaders of twenty years ago have become poor competitors today. Table II gives ample confirmation of this fact. These changes are the resultant of forces, some of which are inherent in the physical characteristics of the properties and others are nothing more nor less than the working out of natural selection and the survival of the fittest in management.

Reserves Large But Indeterminate

All of the districts in which these companies operate either have long records of production behind them with many years of assured activity in the future, or have enormous tonnages of reserves ahead of them. None of them have died yet, and nothing seems surer than the probability that twenty years from now these same districts will all still be represented in the industry, although their relative standing at that time may be greatly changed. The most important change in the last twenty years is the successful exploitation of low-grade disseminated ores. It takes no great stretch of the imagination to believe that the day will come, and shortly, when such ores will be worked profitably on a yield of 10 lb. to the ton. To calculate the probable reserves, in these districts, of material of this grade would require astronomical figures to encompass. The exploitation of the porphyry ores made it possible to supply the war demand and brought about the overproduction since the armistice with which the industry is still struggling. This condition is identical with that produced in the steel business in the 90's by the successful development of the steam-shovel ores of the Mesabi range. The period of depression through which the old established units of the iron mining industry were forced to struggle before the needs of the country caught up with its greatly increased capacity to produce lasted about seven years. In the end they undoubtedly benefited by the improvements and economies which they were forced to adopt to stay in the business at all. In general, these changes brought about a higher degree of mechanicalization of the industry as well as a more thorough integration of its parts, and therefore involved a greater investment per unit of product, offsetting, to some extent, the saving in labor cost. This in itself has helped to stabilize the iron and steel business by preventing further rapid expansion of productive capacity. All the evidence points to a similar sequence of events in the copper industry since 1918.

Referring to Table I, it will be seen that a substantial portion of the 1923 production yielded a greater margin available for dividends than was actually distributed in the pre-war period, and well above the general average of 4c. per pound for the whole known history of the industry. But this apparent improvement cannot be taken at its full face value, because depreciation costs rise with the increase of invested capital per unit of output, and charges for this expense have been inadequate in the past.

Certain differences exist in the methods of handling the cost of depreciation by the various companies. It

should never be forgotten that when a mine is exhausted, the plant has no value, no matter how modern it may be in every respect or how thoroughly it may have been maintained right up to the moment of exhaustion. In this fundamental respect mining and metallurgy differs from every self-perpetuating industry. Strong reasons support the contention that the depreciation reserves to which depreciation charges are generally credited should be represented by cash or readily realizable assets, which would be available at any time for plant changes that the constant improvements in processes may demand to maintain the competitive power of the company. In other words expenditures on plant for such purposes are not additions to capital investment unless and only to the extent to which they result in increased capacity. Nor are they maintenance of plant, but they are the cost of maintaining the company's ability to compete with its rivals by supplying it with the latest and best equipment.

Certain of the companies charge off depreciation against current income, adding to or subtracting from their plant and equipment item only such amounts expended on this account during the year as are in excess of or less than the depreciation charged for the year. Others credit the depreciation to a reserve against the book value of plant and equipment, to which in turn they credit all expenditures not regarded as maintenance. In either case, the resultant cash becomes a part of the current assets. As the purpose of this cash is to supply the wherewithal to make future changes in plant and equipment and not to pay for expenditures already made, it should never be confused with other current assets and thereby included with the funds necessary to finance production and pay dividends. In fact, it should be a credit to a revolving fund from which such expenditures are to be met and into which future depreciation charges are to be paid. Any balance in this fund at exhaustion of the property would be distributed at that time along with any other realizable assets. With this idea thoroughly in mind, it makes little difference in what form these credits and debits are entered on the balance sheet. The amount of such expenditures per pound of production in the past is the best measure of the cost per pound for depreciation in the future.

Depreciation Deductions Important

Failure to regard depreciation as a current cost and to establish a reserve fund into which this cost shall be credited, will sooner or later result in the draining of the working capital of the company, the stopping of dividends, and the borrowing of money to make the changes competition will demand.

To arrive at some definite figures on depreciation costs, I have examined the histories of the following companies: Utah, Nevada Consolidated, and Miami. Utah includes in its facilities to be kept up to date, steam-shovel mine equipment, mills, and a railroad. The smelting of its concentrates is done on contract by the American Smelting & Refining Co. Nevada Consolidated has all the above facilities and its own smelter. Miami has only underground mine equipment, surface plant and mill to provide for. Its concentrates are hauled from its mill by the railroad of the Inspiration Consolidated Copper Co. and are smelted by the International Smelting Co. on contract.

My calculations were made as follows: I have taken the total book value of the assets per pound produced in 1909 for Utah and in 1912 for the other two companies, and determined what total assets would have been required at these rates for their outputs in 1923. I have then subtracted these amounts from the total assets shown on their balance sheets Jan. 1, 1924, including depreciation reserves. The remainders, less the increases in net current assets shown for the periods, I have regarded as the amounts spent on facilities of all kinds to maintain them on a competitive basis in the industry. In considering Miami, it was necessary to eliminate their tax revaluation surplus and depletion reserves from the 1923 figures for comparison with the 1912 balance sheet and add in all depreciation charged off, to put it on the same basis with the others. As would be expected, Nevada, with complete facilities for mining, milling, transportation, and smelting, has the highest cost. Utah, without any smelter, is materially lower, and Miami, with neither smelter nor railroad, has the lowest.

Comparison of Depreciation Costs and Charges

Company	Production	Cost Per Lb. C.	Depreciation (1912) Charged Per Lb. C.	Depreciation (1923) Charged Per Lb. C.
Nevada.....	613,597,436	2.15	1.99	0.85
Utah.....	1,783,184,874	0.71 (1909)	0.49 (1909)	0.85
Miami.....	591,798,436	0.63	0.61	0.63

These figures indicate strongly that depreciation of smelting plant and equipment is the major item in the total cost of depreciation for the industry of copper mining, milling, and smelting or that revolutionary changes in this division of the industry have taken place in the period under consideration which have made it necessary to remodel plants because of improved methods or designs, long before they were worn out. At all events, only one of the three companies, Miami, has allowed sufficient margin in the past to cover the real cost of depreciation, although Utah did charge more in 1923 than its average cost in the past. In all probability the increase is fully justified by the steady pressure to mechanicalize in the effort to maintain or reduce operating costs in the face of higher wage levels. Perhaps the suggestion of a revolving fund to handle depreciation would be of help in keeping attention focused on the question. Any tendency for this fund to appear in the red would be an immediate warning that insufficient charges were being made to cover depreciation cost.

Distributions for depletion, which represents the return of capital investment with interest, can be made from the reserves set aside for this purpose at intervals and in amounts determined by the condition of the working capital of the company and the provisions of the revenue law.

What Is Invested Capital

Having settled the matter of the term of years during which conservative financing points out that the invested capital should be amortized, one is confronted by the problem of determining what the invested capital is. For obvious reasons, an accurate answer could be made only after an exhaustive physical and historical examination of each property. One is, therefore, limited to two estimates; first, the book value placed on their assets by the companies themselves in their annual reports to their stockholders, and second, the value placed by the public on these same assets in the open market.

In Tables III and IIIA, I have shown these two

estimates, together with columns giving the investment per pound of annual capacity based on their 1923 output, and the capital cost per pound to return the principal and interest at 5 per cent in twenty years. In other words, only such return as the investor in twenty year 5 per cent bonds would receive over the life of the investment.

Great divergence has existed in the manner of handling the revaluation surpluses resulting from the valuations made necessary by the Federal Income and Excess Profits Taxes as of the basic date March 1, 1913. In an attempt to put all companies on the same basis, I have taken in all instances the net value of the assets shown after deducting reserves for depreciation and depletion.

Certain companies do not include in their balance sheets their tax revaluation surplus. Consequently they disregard the question of depletion on their income statements and balance sheets.

Therefore the book value of their assets represents only the par value of the securities issued against them, plus any earned surplus. Whether or not it is fair to compare their figures with those of companies that include their revaluation surpluses and depletion reserves, is immaterial, as the public has registered its opinion of the value of the various properties on the open market regardless of differences in the methods of bookkeeping. The function of depletion is to maintain the invested capital of the company intact for distribution to the stockholders over the life of the property. Therefore, to justify the book values shown on the balance sheets, or those placed on the securities in the market, provision must be made to repay that portion of the capital with interest which has not been distributed, or against which reserves have not been set up for this purpose. If these reserves are merely bookkeeping entries, and are not represented by accumulated liquid assets, their repayment depends entirely on current earnings and must come out of working capital.

Mining Dividends Include Return of Capital

From a practical standpoint, the stockholder must regard all dividends paid to him by a mining company as made up partly of return of capital with interest, and partly of profits. Conservatism would lead him to regard all such payments as return of capital and interest until his investment had been liquidated and only after that would he feel safe in considering them as profits. The average investor is usually lost in the mazes of the balance sheet and assumes that the enormous reserves for depletion written up since the present tax law went into effect do represent liquid assets accumulated in the treasury of the company to insure the repayment of his capital.

Column 1 in Table III gives the book value of the total assets in the annual reports for the year ending Dec. 31, 1923, less reserves for depreciation and depletion where they are given. The following companies do not include their tax revaluation surpluses and depletion reserves on the balance sheet: Chile, Utah, Nevada, Inspiration, Anaconda, Ray, Chino, and Greene Cananea. All of them, with the exception of Miami, include their depreciation reserves. The latter company charges depreciation off annually against current income as a definite cost item, debiting the items of fixed capital on the balance sheet with the respective amounts so charged.

Table III.—Financial Statistics of Prominent Copper Companies

Company	(1) Book Value Total Assets Less Reserves For Depreciation and Depletion Jan. 1, 1924	(2) C. Per Lb. 1923 Prod.	(3) Capital Cost to Retire Book Values With Int. @ 5% In 20 Years (8%) c.	(4) Earnings Per Lb. Available For Dividends 1923 c.	(5) Profit or Loss Per Lb. c.
Cerro	$50,253,582	54	4.32	7.27	2.95
Chile	156,980,261	77	6.16	6.30	0.14
Utah	71,839,958	32	2.56	5.10	2.54
Kennecott	190,161,677	55	4.24	5.58	1.34
Miami	8,048,021	12	0.99	3.56	2.57
New Cornelia	33,431,106	87	6.96	3.41	— 3.55
Nevada	29,150,320	45	3.60	3.40	— 0.20
Inspiration	31,837,694	36	2.88	2.35	— 0.53
Anaconda	315,879,677	92	7.36	2.89	— 4.47
Calumet & Ariz	37,031,211	54	4.32	2.54	— 2.42
Ray Cons	31,105,137	49	3.92	1.69	— 2.15
Old Dominion	10,408,266	39	3.12	0.95	— 2.17
Chino	24,071,720	44	3.52	0.36	— 3.16
Greene Can	55,014,505	131	10.48	—0.37	—10.11
Totals and Average	$1,045,213,135	57	4.56	3.80	—0.76

Column 2 gives the total assets per pound produced in 1923, including the proportion of production owned by holdings of stock in other companies.

Column 3 gives the cost per pound to retire these assets with 5 per cent interest in twenty years. To do so requires annual installments of 8 per cent of the amount. (See text for further discussion of length of period.)

Column 4 gives the earnings available for dividends per pound produced in 1923, including the proportion of production and earnings represented by holdings of stock in other companies.

Column 5 gives the profit or loss per pound in 1923 after providing for return of capital and interest under column 4.

The totals necessarily include duplications, but the average per pound is nevertheless representative.

Table III-A, which follows, is similar in every respect excepting that the market value of the securities outstanding on June 11, 1924, is used in column 1 instead of the book value of the total assets.

Table III-A—Financial Data Based on Recent Market Quotations

Company	(1) Market Value of Securities Outstanding June 11, 1924	(2) Value Per Lb. Based on 1923 Prod. c.	(3) Capital Cost to Retire Purchase Price In 20 years With Int. @ 5% c.	(4) Earnings Per Lb. Available For Dividends 1923 c.	(5) Profit or Loss Per Lb. c.
Cerro	$45,419,490	49	3.92	7.27	3.35
Chile	141,841,677	69	5.52	6.30	0.78
Utah	110,159,198	49	3.92	5.10	1.18
Kennecott	160,374,328	45	3.60	5.58	1.98
Miami	14,942,280	23	1.84	3.56	1.72
New Cornelia	32,850,000	85	6.80	3.41	— 3.39
Nevada	24,992,941	41	3.28	3.40	0.12
Inspiration	24,082,578	27	2.16	2.35	0.19
Anaconda	256,962,240	74	5.92	2.89	— 3.03
Calumet & Ariz	27,950,055	41	3.28	2.54	— 0.74
Ray Cons	25,771,890	26	2.08	1.69	— 0.39
Old Dominion	6,168,750	23	1.84	0.95	— 0.89
Chino	15,300,000	28	2.24	0.36	— 1.88
Greene Can	5,500,000	13	1.04	—0.37	— 1.41
Totals	$882,215,327	48	3.84	3.80	— 0.04

Eliminating duplications due to stock ownership, about 1,100,000,000 lbs. was produced in 1923 at cost, which would show a profit after amortization of purchase price with interest at 5 per cent over a period of twenty years. After that period all dividends earned would be entirely profit.

Some explanation is due in the case of New Cornelia. This company is now equipped to produce between 6 and 7 million pounds per month, which would reduce the figures in Columns (2) and (3) to 45c. and 3.6c. respectively, thereby reducing the loss in Column (5) to —0.21c. Similar adjustments may be in order in other cases, which individual study would disclose.

Before passing to any conclusions to be drawn from the facts set forth in these tables, consideration must be given to the question of the amount and character of working capital of net current assets owned by this group of companies at several stages in their history. In this manner, one may be able to form some opinion of the requirements of the industry in this important respect. Of course any determination of the net cur-

rent assets of a corporation necessarily hinges on the interpretation of the degree of liquidity required to distinguish current items from deferred or fixed on both sides of the balance sheet. My own definition is based on the conception of the function of working capital as a fund from which cash can be continuously supplied to pay the cost of production, and from which cash distributions to stockholders can be made. Unless otherwise provided for, it must also supply the cash with which improvements in plants and processes can be financed—that is, with which the cost of depreciation can be met. This fund of cash is constantly replenished by the receipts from sales of product. Therefore, only items which can be immediately converted into cash for the satisfaction of the above needs are current assets.

Table IV, following, shows the net current assets or working capital per pound of production at several dates during the 13-year period which has been studied, owned by the companies in the same group.

Table IV—Comparison of Working Capital Per Pound of Product

Company	Jan. 1 1911, Cents	Jan. 1 1916, Cents	Jan. 1 1921, Cents	Jan. 1 1924, Cents
Cerro de Pasco	N. A.	N. A.	14.3	19.6
Miami Copper	N. P.	6.7	2.4	12.8
Chile Copper	N. P.	6.4	22.8	12.7
Nevada Cons.	4.0	11.4	18.1	11.9
Ray Cons.	N. P.	6.8	17.3	11.5
Calumet & Ariz.	13.2	10.6	14.5	9.1
Utah Copper	3.7	9.0	20.7	8.3
Anaconda	7.0	7.5	....	....
Greene Can.	6.0	3.0	15.8	4.8
Inspiration	N. P.	13.1	11.6	3.2
Old Dominion	2.8	3.4	....	2.6
Chino Copper	N. P.	8.8	7.9	2.4
New Cornelia	N. P.	N. P.	10.3	1.8
Braden Copper	N. P.	Deficit	Deficit	Deficit

N. A. means not available; N. P. not producing.

Note 1. Chile Copper Co. Jan. 1, 1924, balance sheet lists as current assets "Supplies on hand and expenses prepaid," an item of $6,463,556. For about the same production Utah Copper lists no prepaid expenses and "Materials and supplies on hand" $2,401,193. Therefore it is probable that some $3,000,000 of the Chile item represents prepaid stripping expenses and should be omitted, bringing the figure per pound down to about 11c.

Note 2. Anaconda Copper figures for the last two periods have been omitted, because of the confusion arising from the inclusion of the American Brass Co.'s inventories. It is probable that the total cost of producing the 500,000,000 lb. of brass and copper products by this company in 1923 was about 16c per lb., or $80,000,000. The working capital of the company at the close of the year is given as $82,680,714.

Prepaid expenses unless promptly returnable in the form of product are not liquid. For example: prepaid stripping expenses in steam-shovel mining cannot be regarded as a liquid asset under such a definition. They represent money expended in development work preparatory to mining ore, made necessary by the choice of this method instead of underground mining. In the latter case, money would have been spent in the sinking and equipment of shafts, driving and equipping of haulage levels, cutting of ore pockets, raises, etc.

In the former method the amount needed is so large compared to the total cost of mining, before any returns can be realized, that it has seemed wise to most companies using it, to make special provision for its return by crediting it to a deferred account on the asset side of the balance sheet, and debiting this account with a charge to operating cost of a fixed amount per unit of production based on the total product whose extraction has been cheapened by the expenditure. Similar provisions for the retirement of the cost of preliminary development have been made by nearly all of the underground porphyry mines where its proportion of the total cost is also high.

In general the test of liquidity is whether the item under consideration can be used at its face value to pay off current indebtedness. Supplies and materials on hand at the mine and plants may properly be regarded as liquid assets, although in few cases, if any, could their full cost be recovered at a sale on account of the limitations of a local market and the cost of handling and freight to some other market. Bills receivable for product sold and product on hand and in process come next in order of liquidity, and finally, negotiable securities and cash.

On the liability side, there is not much room for differences of opinion in distinguishing fixed, deferred, contingent, and current items.

In general the amount of working capital or excess of current assets over current liabilities required to finance production comfortably, depends on the cost of the product and the rapidity of turnover. For example, gold which is immediately convertible into currency when produced represents the most rapid possible turnover and theoretically only sufficient working capital would be necessary in gold mining to finance the cost of one day's output, or, for convenience in handling payrolls and purchases of supplies, not more than one or two months' production. As a matter of practice, however, a number of examples might be cited from the important gold mines of the world, where the cost of nearly a full year's output is kept continuously on hand in the working capital. In anticipation of the payment of dividends, cash must be allowed to accumulate in the working capital in sufficient amount to meet such outlay without embarrassing current expenses of production. Similarly improvements and extensions which are to be financed from earnings will require accumulations of cash. Copper, now being the equivalent of currency, will take somewhat longer to convert into cash than gold. The experience of the industry as a whole would indicate the desirability of maintaining the level of the reservoir of working capital at about the height of one year's production cost.

Earning Power Depends on Ample Capital

Study of these figures in Table IV, alongside of those in Table II, indicates pretty clearly that ample working capital and strong earning power go together. They are mutually interdependent. The first four companies in earning power in 1923 were among the first seven in working capital per pound of output. Ray and Calumet & Arizona, which stood ahead of Utah in the latter respect but were well below her in the former, are at present called upon to furnish the working capital needed by Chino and New Cornelia respectively, as well as their own. On the other hand, the four companies with the lowest earning power in 1923, with the exception of Ray, stand near the bottom of the list in amounts of working capital per pound of production owned by them at the end of the year. Similar comparisons with conditions during the earlier periods cited in the tables show this same relation to hold generally true.

The condition of the working capital indicates the balance between earnings and the amounts distributed as dividends and the expenditures for improvements or expansion of facilities. As I have already shown, in the discussion of depreciation, those companies having most complete facilities require the largest working capital in proportion to their capacities. Failure to maintain sufficient working capital will result in damage to the interests of the stockholders in one or all of the following ways. First, by the resulting inability to make the improvements necessary to maintain com-

petitive power. Second, by the resulting inability to continue the payment of dividends. And third, by the necessity of borrowing money to finance current production or make improvements.

Another less obvious advantage of ample working capital is that to perpetuate the operations of a mining company, it is manifestly necessary to search for and secure additional properties from time to time. The possession of an adequate supply of cash renders this easier and cheaper.

Good Management Essential

All these considerations point directly to the importance of management in the success of the enterprises. Companies fail and succeed with the ebb and flow of the intelligence controlling their destinies. Mineral in the ground is not an asset unless possessed by an organization which can extract it profitably in the face of keen competition. The most modern plant for the purpose is worthless in the hands of incompetents. Such axioms are the merest platitudes, but are often overlooked in the abnormal psychology of the search for "buried treasure." In the long run, bad management will furnish its own cure. My sole reason for referring to the question here is to point out that a closer study by directors and stockholders of the comparative results obtained by their competitors might lead to the correction of some of the worst faults of management and so hasten the return to normal of their share in the prosperity of the industry.

Earnings Not All for Stockholders

It is not safe to assume that the earnings available for dividends in 1923 as reported by these companies could be distributed in full. As I have shown from the examples chosen, probably most of the companies have failed in the past to provide adequately for the cost of depreciation, and there is little reason to believe that they will be any less optimistic in the future, excepting so far as the bitter experience of seeing their working capital diminish through constant withdrawal for improvement of facilities, as well as the payment of dividends, may dictate temporarily at least the withholding of a portion of current earnings from distribution. On the average, however, I believe that it should be quite safe to assume that 2.6c. per lb., or 18 per cent of the price received and 70 per cent of their net earnings in 1923, might have been distributed as dividends. The policy to be pursued by the individual company would necessarily be determined by its financial situation and the competitive condition of its plant and equipment. As a matter of fact only eight out of the fourteen paid any dividends in 1923. The total, omitting duplications, was $32,967,201, or 66⅔ per cent of their total earnings reported available. The figure per pound was 2.4c. It would appear, therefore that without further increases in the cost of production, a rise in the price received from 14.41c., the average for last year, to 15.46c., would restore the pre-war average distribution for the whole group of 3.67c. per lb. and still leave a margin of 1c. per lb. to cover any deficiency in depreciation charges. At the same time, as I have pointed out before, such an increase in price would raise the earning power of the present leaders to a level unprecedented save in war time, and therefore tend strongly to prevent its support at this level for any extended period.

It may be concluded therefore, first, that 1923 found the earning power of the copper industry restored to approximately 75 per cent of normal. Second, that any increase in the market price of the metal above 15½c. for the next few years, or until the world's demand has fully overtaken the present over-expanded facilities of the industry, is extremely unlikely. Third, that the competitive power of the various units of the industry has varied between wide limits in the past and will continue to do so in the future. In the language of the Scriptures, the first shall be last and the last shall be first; whereas the average net earning will remain fairly constant in the neighborhood of 4c. per lb., or 25 per cent of the price received. And fourth, that the burden of increased taxation, as well as the greatly increased investment per unit of capacity required by the handling of low-grade ores, and the higher wage levels, make the accurate determination of capital cost and depreciation cost a matter of vital importance to sound management and intelligent investment.

Recent conditions, with copper selling at 12½@13½c., are the continuing result of the same forces that have been in control since the armistice—namely, the imperative necessity of reducing costs to show adequate earnings on expanded capacities, with Europe still suffering from stagnation and unable to take its normal proportion of the world's supply of the metal.

There has been a great deal of idle talk about community of interest among the producers and a general curtailment of production, but the facts to date show little lessening of output. A fair proportion of the total output is still being produced with a comfortable margin, although it is doubtful if the business is really profitable whenever this margin falls below 3½c. per lb.; that is, below that rate of return there is a loss of the capital investment. Everybody is waiting for the other fellow to do the curtailing because to do so inevitably means higher costs. The law of supply and demand works inexorably and those unfortunate and misguided ones who expect aid from their more successful rivals will appeal in vain. Their one hope of raising themselves from the ignominious position of "marginal producers" to that of active competitors lies in equipping themselves with the very latest 1924 model, throwing out all unnecessary weight, stepping on the gas, and giving the other fellows their dust.

Midyear Conditions in New Mexico

Production of metals in New Mexico during the first half of 1924 showed no great change from the rate of production in 1923, when the total output was $11,573,805—an increase of $5,675,359 over that of 1922, according to the U. S. Geological Survey. In 1923 the mines produced $551,713 in gold, 747,127 oz. of silver, 61,356,802 lb. of copper, 3,832,427 lb. of lead, and 16,496,000 lb. of zinc.

During the first half of 1924 the Chino division of the Ray Consolidated Copper Co. completed the remodeling of four sections of the plant and now reports that the results of the improvements made have gained all that was expected in economy of cost and in recovery.

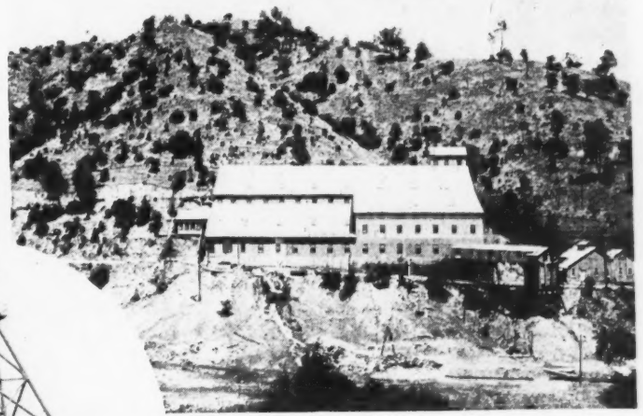
A notable increase in the production of gold and silver was made during the first half of 1924 at Mogollon, where the Mogollon Mines Co. enlarged its operations by taking over the Fannie mine and mill. The mines in Sierra County continued to contribute smelting ores carrying silver.

Active Gold Producers of California

No.8 Gold Dredge
Natomas Co. of California

Argonaut Mine and Mill, near Jackson

Kennedy Mine
near Jackson



Milling Plant, Eagle-Shawmut Mining Co.

Plymouth Mine
Plymouth

Central Eureka Mine, near Sutter Creek

Empire Mines, Grass Valley

California Leaders in Gold Mining

C.W. Gardner

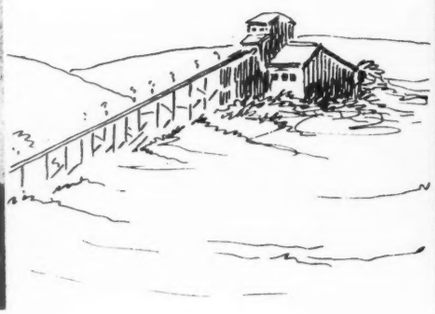
E. C. Hutchinson

L.D. Hopfield

F.W. Bradley

W. P. Hammon

W. J. Loring



A. B. Foote

Factors in Mine Cost Accounting

Intricate Decisions Involved When Working Charges Are Analyzed and Apportioned

By Benjamin F. Tillson
Mining Engineer, New Jersey Zinc Co., Franklin, N. J.

IT HAS BEEN SAID that "costs are a state of mind." Although this seems an extravagant statement, an increasing familiarity with the nature and origin of cost data will bring to one the realization of the germ of truth in the above-quoted trite expression, for it will be evident that the points of view of all of those who contribute to the accounting system in an organization are responsible for the final figures. Regardless of the ability of those who assemble cost figures, they rely for their accuracy upon the correctness of the viewpoint of those responsible for their origin, and as a rule the workmen or foremen with whom the charges originate have only a meager idea of the accounting scheme with which they should co-ordinate. But even though the charges are correct in their sources, and all of the clerical work in handling them is exact, there are many opportunities for a difference of opinion in the handling of the figures. This makes the comparison of cost data between two different organizations very deceptive, because no cost statement gives a complete history of the way in which the conclusions were reached.

ALTHOUGH accounting is a useful science which analyzes the financial status of any business enterprise, it generally requires the making of arbitrary decisions that can alter materially the complexion of the final account. Particularly is this true of the allocation of working costs. Mr. Tillson asks numerous pertinent questions regarding current accounting practice as followed by mining companies, with the hope of stimulating discussion of this interesting subject. He gives numerous illustrations to support his conclusions that incorrect accounting procedure is often being followed and that a modification of the practice would be beneficial to the industry.

Practice Widely Variable

It is the object of this article to draw out discussion of some accounting practices that may be controversial and to solicit arguments for the justification of any definite practice proposed by those who enter into the discussion. No attempt will be made to cover all the controversial methods in accounting, but it is hoped that the lapses will be filled in by the discussions of other persons.

It seems that many decisions in accounting must be arbitrary. Where should the line be drawn between capital expenditure and working costs? Perhaps theoretically it should be decided as to what extent a mine should be developed and equipped to produce an intended tonnage per day and the cost of such work charged to capital investment, allowing a certain credit to the capital account for the ore produced in development. Then any addition to the equipment or development work required for an increased tonnage rate would necessitate added capital expense, but any replacements of equipment or new development work to open a tonage of ore equal to that exhausted should be chargeable to the working costs. But because of the usual intermittent nature of such additions, only a very profitable enterprise can permit of the absorption of such costs by the tonnage of ore produced in the period in which the expenses occur, so some reserve fund or suspense account may well be established to distribute these charges uniformly over the tonnage which they benefit. Maintenance Reserve and Development Reserve accounts would accomplish such a result, but bring into force the human errors of estimates.

The boundary lines between capital, maintenance, and operating charges are often very vague. Suppose we have forty mine cars as our electric haulage equipment; that we have been using them for fifteen years, and that a reasonable life for them is twenty years. Must we now charge any new cars to capital investment on the score that they increase the mine equipment, or, on the basis that our present equipment can give only 200 car-years of service out of an original 800 car-years of expected use, are we warranted in buying thirty new cars and charging them to a maintenance account? If this principle is right, let us suppose that the cost of such cars is now double what it was fifteen years ago and then decide whether we are justified in a maintenance purchase of only fifteen new cars. The factor of degree may enter into our decision for similar cases. For instance, shall we treat our rock-drill equipment differently or shall we ignore the number of units we have in operation and buy against maintenance all the new drills we require both to overcome depreciation and obsolescence and to meet sporadic demands for increased production? It is evident that we must buy the new cars and drills in advance of our scrapping the old ones or we could not maintain our production, so is there any reason why we should not buy them to meet a temporarily increased need for such equipment to benefit mining conditions? And how about our mine shovels? Why should they be charged to operating supplies instead of capital or maintenance.

How Development Charges Are Complicated

Suppose we have planned for a certain number of rock drifts in our capital investment for mine development and some have been caved because they were too close to the orebody or others have been improperly located, or insufficient in number to meet our needs as we now realize them; is it proper to charge the new ones to capital expense and penalize that account for our lack of foresight, or should not our costs of produc-

ing ore directly bear this burden in a Deadwork or Development account?

All of our costs are possibly complicated by the following factors: We do not do in any month just the work necessary to produce the particular ore we hoist, so we either profit from some past work or lay up a debt against some ore to be mined in the future. We break from the solid a different quantity of ore and at a different unit cost than the ore we tram and hoist. We may place an amount of fill which is not equivalent in its cubiture to the solid tonnage of the ore hoisted. How will we handle these differences? Consider, for example, the item of broken ore reserves in the mine. Some accountants, when it suits their objects, will put much stress on "true costs" and indicate that they refer to the costs of the particular units of ore under consideration. For instance, if some cars of ore which are received at the smelter are dumped directly upon the charging floors and some go to the stockpiles before being used, the latter receive an extra burden for stocking and loading again. The excuse for such a procedure is that they are the "true costs." It is hardly likely that the same method would be applied to the broken ore reserves in the mine, where, because of the difference of operating costs in different stopes and at different times and wage scales, the same distinction could be made between the ore freshly mined and the broken ore reserves. However, although it may seem inconsistent, such distinctions are being made. But are they proper or wise?

Let us consider the application of this policy to smelter stocking. It would seem that the "true cost" system encourages either subconscious or concious tendencies on the part of one whose cost records depend upon the inclusion of stocking charges to make a better showing by the use of ore as directly received, although, because of the grade, it might be more to his company's advantage to have used a part or all of his ore from the stockpile. Also, such a policy seems unsound because it ignores the true principle of insurance which justifies a stockpile. The cost of such insurance should surely be borne by all of the ore handled, whether from the stockpile or direct. One would scarcely count upon paying all fire insurance or accident liability premiums only in the months in which losses occurred, and yet such a practice would be equivalent to making a differential penalty on ores, fuels, or other supplies taken from storage.

Use of a Stock Inventory Account

The proper handling of this problem could be simply and directly accomplished by keeping a reserve inventory or stock inventory account. This account should be inflated by the total tonnage received and its cost, whether applying to material used direct or stocked, and for each month unit costs should be calculated after handling and carrying charges had been added to such account, and then all of the material used should be charged out at such a unit cost, whether or not it had been stocked, and the tonnage and value so charged out should be deducted from the account.

For a large mine how can we arrive at a real monthly working cost per ton of ore? A casual consideration may lead us to feel that the solution is simple, and we will attack the problem in one of two ways. We may divide our total expenditures by the tonnage of ore we have hoisted. But will we have a true figure if, as is more than likely, we have broken or trammed a different tonnage than we have hoisted, or have done a disproportionate amount of timbering or deadwork, or if we have placed an amount of filling different than the equivalent volume of solid tonnage of ore we have hoisted? Perhaps to meet the above difficulties we have prorated each of the above-named subdivisions of our mining against the particular tonnages they have served, and so have derived a series of unit costs. For instance, we have charged the cost of breaking ore from the solid against the actual tonnage broken; we have rated the cost of filling against the tonnage of ore so replaced; we have charged the cost of hand-tramming against the tons so transported, our electric haulage costs against the tons so handled, and the pumping, hoisting, and general departmental charges against the tonnage hoisted. What shall we do about deadwork, development, and timbering charges? Perhaps we will conclude that it is reasonably fair to rate the first two against the hoisted tonnage and to distribute that part of the third which applies to general maintenance of the levels against the same tonnage and let the breaking of ore carry the stope timbering and the tramming bear the cost of chute building and repairs. Having satisfied ourselves that these are reasonable arbitrary decisions, we may feel that in the summation of all of these and similar unit costs per ton we have achieved a true working cost. It may be the best that we can arrive at for the comparison of our mining efficiency between monthly or other intervals, but it does not represent either a production cost or a real working cost, for each ton of ore does not require each of these unit operations. For instance, some ore may require both hand tramming and electric haulage and some only one of either of these operations, and yet our cost burdens it with both. What better can we do?

Allocation of Working Costs

Although our accounting pitfalls have been many, we have not yet stumbled into that one which is fraught with the greatest danger to our enterprise—namely, the allocation of distributable working costs.

A distributable working cost may be defined as that cost applying to the simultaneous or joint production of two or more products by a process necessary to separate these products—for example, the magnetic or hydraulic separation of two ores or minerals.

The fundamental principle is proposed that such products should bear their proportionate share of any distributable working cost which is responsible for them, in accordance with the proportion of the net profit from each product to the total profit on all of the products involved in that operation. On the basis of the above-named method, the conclusion might be hazarded that the total cost of mining and milling should be proportioned to the net value of, or the net profits derived from, the marketable products. Such reasoning, however, does not seem defensible, as it does not permit an analysis of the milling treatment which may be profitably applied to the crude ore, to get the maximum dollars of profit by separating it into products which cumulatively will give a greater net return than could be obtained from the crude ore if it were smelted direct. An elaboration of the application of this principle may be desirable for the consideration of its soundness.

Suppose we are concentrating an ore of lead and zinc sulphides: how shall be determined the cost of producing

the different products? Shall we apply the above-named principle for distribution of working costs, and how shall we do so?

The working costs of the ore hoisted (and picking table rejections should be included as ore hoisted) should include the depletion and depreciation of the mine orebody and equipment, with taxes on the same; and general superintendence, compensation reserve, and office expenditures should be proportioned to the payrolls of the various mining and milling departments; and other general expenses like sociological, change house, and safety, should be proportioned to the number of men working in each department. Supply-house charges should be distributed against the value of the material issued, and power should be charged in accordance with the units used in each department. These costs per ton should follow through on the ore crushed and sized until it is ready for the first mineral-separating process and should accumulate the costs of such preparation.

Let us assume that the desired products are galena and sphalerite, that the ore is much like the typical Joplin ore, and that the milling practice is similar to that shown by the flow sheet on page 1719 of Peele's "Mining Engineers' Handbook."

Crush ore through $\frac{5}{8}$ in. and then rough jig with hutch products to a cleaner jig to make coarse lead and zinc shipping concentrates, respectively. The heads of several final compartments of both jigs and the overflow of rougher jig are both crushed through $\frac{5}{8}$ in. and treated in a rougher jig, and its heads and hutch products crushed through $2\frac{1}{2}$ mm. are treated in a cleaner jig to produce separate lead and zinc concentrates of a smaller size.

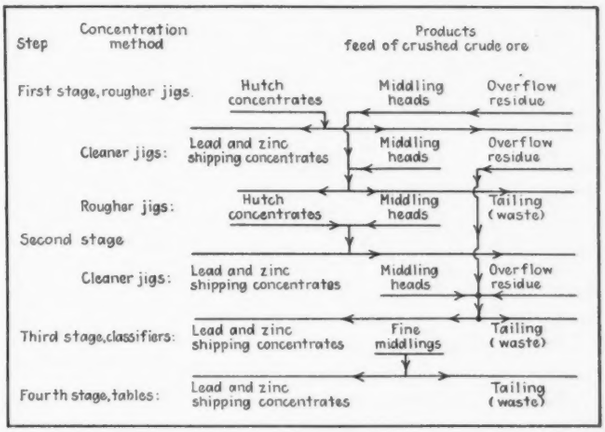
The overflow from the second-stage rougher jig is waste tailing; that from both cleaner jigs is added to the mixed lead-zinc middling product from the last cleaner jig and is screened and crushed to under $1\frac{1}{2}$ mm. and classified to obtain lead and zinc fine concentrates for shipping, a middling product which is re-circulated, a fine mixed product which is tabled to obtain lead and zinc shipping concentrates, and tailing from both classifiers and tables. So there is ultimately obtained lead and zinc sulphide concentrates, respectively, of four different sizes and possibly of different analyses, and each size smaller has entailed additional cost for its production. In addition there is tailing which may or may not have some value for reworking or other purposes. The flow sheet of the products is indicated by the accompanying chart.

Each Product Has Its Own Problem

Some may argue that all of the sizes of lead concentrates and zinc concentrates, respectively, should be combined and figured at an average cost, or that all of the concentrates should bear but one average cost. However, is such a stand sound? Should we not carry our costs so that each product resulting from finer grinding and additional processes of separation will bear its added burden? If not, there is no limit to the amount of work we may be tempted to do upon the tailing, until we have exhausted all of the profit we might have made from the easily separated coarse concentrates.

The lead and zinc concentrates will probably each have a different market value per ton, and these should control indirectly the distribution of our working costs in each step, for, obviously, if the market value of one should seriously fall, and we distributed our working costs on the tonnage of concentrates produced in each stage (irrespective of their mineral nature), we might be producing one of them at a book loss, although the other would show an overbalancing profit. And if one had no value (in the same class as tailing), there would be no hesitation in debiting all of the working cost to the other, even though we were accounting on a tonnage basis of salable concentrates instead of a net profit basis.

In the first stage of rougher and cleaner jig concentration we obtain six products of relative value which should bear a proportionate part of the working costs



Flow sheet showing products of concentration obtained in hypothetical case referred to in test

up to and including this stage. These are coarse lead concentrates, coarse zinc concentrates, two coarse middling heads, and two coarse overflow residues. The simple distribution would be based upon the relative metallic content value of each product, but such a procedure would be unfair, as the middling heads and overflow residue require more work and expense before they can be shipped, and, furthermore, the total expense up to this point must be considered to determine whether there is still a margin of profit which will permit doing this additional work. But the distributable cost of this additional work involves, as well as concentrates, a middling product which may be workable, and again this cycle occurs up to the third stage of concentration. So how can we arrive at the net profits available from such middling products?

It would seem advisable to attack this problem in the following manner: Determine the working costs per ton of feed for each of the four stages of concentration and start calculations with the final stage of concentration. If the market value of the products we obtain from this final tabling does not materially exceed the cost of making them, we are not warranted in continuing this stage of concentration, for we are in business for a profit, not for the satisfaction of "turning over an old dollar for a new one." Of course, there may be times when, to hold an organization together, we are willing to forego our profit, but if such times become frequent it would be better to expend our capital and devote our energy elsewhere.

The importance of the charging of working costs with departmental segregation of depletion and depreciation, as well as a proportion of general expenses, now becomes

apparent, for we may otherwise be fooled into carrying our concentration to a point where it is really losing money or at least absorbing our attention without remuneration.

In the fourth stage, the difference between the shipping value of table concentrates and the working cost of that departmental operation indicates a value for the fine middlings made by the classifiers, the third stage of concentration. The working costs for the third stage are then subtracted from the shipping value of the concentrates so produced, and to this difference is added the value of fine middlings already estimated. The total should show a satisfactory profit if we are to employ this third stage, and the working cost should be distributed against each of these two products in accordance to the ratio of the value of each to the sum of their values. We are now in position to calculate what we may term "a gross working profit" upon the concentrates from the classifiers and tables, but we must later deduct from these figures a proportion of the cost of mining the ore before we can show the net profit applying to these products. We cannot determine this proportion until after we have found the "gross working profits" applying to the concentrates from the two stages of jigging.

By deducting the working cost in the classifier department from the above-noted value of the products, we estimate a value for the feed to this department, and we here find a complication in the fact that this feed is comprised of products from both of the first two stages of concentration—the overflow (or residue) from the second stage cleaner jig as well as the middling concentrates (or heads) from the two middle compartments of the same jig. To proportion the relative values of these products, recourse must be made to a special analytical investigation as to their relative sizes (and their bearing upon subsequent crushing cost), their mineral contents (and their value), and the dissemination of mineral values (and the relative possible recoveries, cost of crushing to make such recoveries, and possibly lessened value because of the fine size of the concentrates and the increased smelting costs and poorer smelter recoveries thereby resulting). From our judgment in this investigation we should be able to assign a reasonable relative value to each of the metallic units in these various products, and we can safely apply such factors in the future to the analyses of these products In this way we can apply values to these middling products as obtained from the first two stages of ore concentration.

Numerous Calculations Required

By adding the values so obtained for the middling and overflow residue products of the second stage cleaner jig to the value of the shipping concentrates obtained from this jig, and by subtraction of their corresponding proportions of the total cost of the rougher and cleaner jig operation and its preliminary crushing and screening in this stage of concentration, we get values for the "gross working profits" applicable to the lead and zinc shipping concentrates and the middling products from the second stage of jigging concentration. The sum of these values gives the value of the feed to the second stage, which is composed of concentrates from the last four compartments and the overflow residue from the first rougher jig and concentrates from the last compartment of the first cleaner jig. The value of these products may be fairly proportioned to each other on the basis of the values of their metallic contents. To the values of these products should be added the value of the coarse lead and zinc concentrates shipped from the first-stage cleaner jig, and the working costs should be proportioned in accordance with these values, and by subtracting these costs we obtain "a gross working profit" for the lead and zinc concentrates shipped from the first stage of concentration and for the middlings likewise produced. The sum of these indicates the value of the crushed sized ore as fed to the jigs. If the cost of crushing and sizing is deducted from this value we would have a maximum value for the crude ore produced from the mine, and the difference between this crude ore value and our mining costs would indicate our profit. Such a procedure would show all of the profits as credited to the mining of the ore. It is necessary to have such information in order to determine the extent to which low grades of ore may be mined profitably and to determine whether certain mining methods are commercially practicable.

If it were desirable to mine without profit and show all of the profits as applying to the concentrates shipped it would be necessary to proportion the working costs of mining, crushing, and sizing for feed to the first jigs in accordance with the relative values of the "gross working profits" already determined for the various shipping concentrates, and then these proportional working costs of mining and crushing should be subtracted from the "gross working profits" to determine the "net profits" on each of the concentrates shipped.

The Purpose of Cost Analyses

As has already been mentioned, we should remember that we are in business for a profit, and so it would seem wise for us to add to the working costs of each subdivision (or department which produces different products) a minimum acceptable percentage of profit based upon the invested capital in that department and the expenses of running that department. This will aid us to avoid doing any work on the ore which is not profitable and will allow us to show the excess profits as credited either to the tonnage mined, or to the various shipping products as already outlined, or, as would appear preferable, to apportion such excess profits in accordance with the ratio of the working costs in each department to the total of all the working costs.

In analyzing costs as we have suggested it is evident that by starting at the final product and working the cost back we first determine whether we have carried our process beyond "the point of no loss." If we have not, and if the cost of flotation or some other method of concentration is less than the value of the additional minerals we can recover from the tailing, we are warranted in extending our process and crediting the profits as a value of the tailing to be included in the values of products in the departments making it. If, however, we have discarded the tailing on a waste pile as of no value, and the other products have paid for it, and we later discover a profitable way to rework it, then such tailing can be assumed as a byproduct with no carrying charge except working costs.

A simple way to avoid the pitfall of nonproductive expansion of manufacturing operations might be to proportion to each productive operating department a part of all general main company accounts, such as amortization of capital, depletion of plants, taxes, ad-

vertising, research, sales and main office expenses, dividends, and surplus for plant expansion. The basis for this distribution will undoubtedly be a subject for much difference of opinion, but it is suggested that for each department there be an estimate of the capital outlay for its plant equipment and to this be added the amount of cash capital resources needed to meet payrolls and stocks of supplies and products required by the fluctuation of operating and marketing demands, or, in other words, the production turnover factor. Each productive department should then be burdened in proportion to its total of such estimate as compared to the similar grand total for all the departments.

It is hoped that the soundness of the above-recorded suggestions for distributing working costs may be developed by the discussion provoked by this article, and, even though proved wrong in his conclusions, the author will feel rewarded for his effort of presentation if he succeeds in calling attention to some other system which correctly solves this intricate subject. The need for a general knowledge of a correct solution must be evident, but a simple example may be worth while to indicate that it is not of only academic importance. Let us think of a copper mine and smelter which has a reputation as a low-cost producer. Let us also assume that it produces silver and gold as byproducts of its copper, and, as may be often the case with byproducts, the returns from marketing these byproducts are applied to the general company expenses and working costs of producing the copper. Under such a condition it is possible that the returns on the silver and gold may approach or equal the money received from the copper, and yet if they are thought of as byproducts they will not be charged with definite mining, milling, and other costs, and so run as a separate branch of the business. Accordingly, some of the principal assets of the company have been ignored in calculating the low copper costs which have benefited by them and the company may be encouraged to squander such assets by vigorous competition in a low copper market, when it would not if it realized that its true copper costs were much higher. Surely, if the gold and silver were an asset in the bank (even though it drew no interest), the company would not apply it to the operation of its property to produce copper for sale at a price lower than its cost, and yet the situation would be parallel to the foregoing example.

How the World's Largest Sapphire Was Discovered

The largest sapphire jewel in the world, which, its value unsuspected by its possessor, was used as a paperweight for many years, is on display at the British Empire Exposition at Wembley. The jewel is a symbol of the god Shani (Saturn) and there is a superstition that those who possess it embrace prosperity and glory. Nine hundred and sixteen carats in weight, this sapphire has the form of a plucked flower with a few leaves around the stem. About five years ago it was discovered by Mr. Wakefield, Director General of Revenue, Hyderabad, Deccan, when visiting Raiz Ahmed, an official of that Indian state. On entering this gentleman's office, Mr. Wakefield discovered the sapphire being used as a paperweight.

The history surrounding the stone is as interesting as its value. It is said that one of the Ballalla kings during the twelfth century, when on a pilgrimage to Ceylon, was given the sapphire, now called the Raiz Ahmed sapphire, by a Buddhist monk. At this time the stone was oval in shape, and was altered by expert engravers when taken back to Mysore. During the reign of the King the stone became an object of veneration, but was afterward captured by Malik Kaffur, the general of Allauddun. Subsequent adventures brought it into the possession of Raiz Ahmed's family in 1798, where it remained until discovered by Mr. Wakefield.

New Type of Electric Furnace Devised

An indication of the incredibly high temperatures which can be obtained by electrical means is the new radiant resistor furnace described to chemists at the recent meeting of the British Association for the Advancement of Science at Toronto by F. A. J. Fitzgerald, of Niagara Falls. Mr. Fitzgerald showed how it is not necessary to subject substances directly to the passage of the electric current in order to make them very hot, as they can be made uncomfortably warm simply by exposure to the radiant beams from a coil made of poorly conducting material through which the electricity flows. Heat is generated as the electricity forces its way through the coil, and the rays are sufficiently potent to melt the charge in the furnace. Mr. Fitzgerald's address outlined experiments which have been carried out on a large scale recently.

En Route to the American Mining Congress at Sacramento

The Overland Limited at Colfax station, California, the junction point for Grass Valley

News of the Week

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Summary

THE Great Northern Ry. has made plans to replace the present wooden iron-ore bins at Allouez, Wis., with a new steel and concrete structure at a cost of approximately $2,000,000. The work will be completed for the shipping season of 1926.

Exportation of zinc concentrate to Europe from the Joplin-Miami district is the object of a new company formed by Frank C. Wallower and associates.

Officials of the Porcupine Davidson Mines Co., of Ontario, are involved in an alleged fraudulent transaction involving the property of the company.

The Dunwell Mine, in the Portland Canal district in British Columbia, promises well.

The driving of 600 ft. of tunnel in one month on the project of the Pacific Gas & Electric Co., in California, is claimed as a record by those responsible for the achievement.

The Natomas Co. of California is moving its No. 10 steel dredge to a new site. The boat was entirely dismantled.

Mining in The Pas district in Manitoba is stimulated by the plan of the Bingo Gold Mines Co. to build a large milling plant.

The program for the annual meeting of the American Mining Congress to be held at Sacramento, Calif., from Sept. 29 to Oct. 4, has been announced.

New Organization Formed to Enter Zinc Export Field

Belgium Expected To Be Important Buyer—Australian Shipments Go to England—Test Consignments Satisfactory

An arrangement has been consummated between Frank C. Wallower, of the Golden Rod Mining & Smelting Co., Joplin, Mo.; E. H. Wolff & Co., Joplin, and The Hirshler Metals Co., of New York, whereby this combination will handle sales of zinc concentrates to European consumers. Sampling, weighing, and loading the concentrates in the Joplin district will be under the supervision of E. H. Wolff & Co., whereas the financing of shipments, chartering of vessels and other details relating to export matters will be attended to by Louis Hirshler, of the Hirshler Metals Co. This organization expects to make sufficient economies in buying zinc concentrates for export to reduce materially their cost to European consumers. Purchases will be made from the bins of producers in the Middle West and a commission obtained from sales to European smelters.

The railroads have been asked by the organization to make a lower rail rate from Missouri points to the Gulf on export shipments. A lower ocean rate will be secured. Inquiries for purchases will be handled by Mr. Hirshler.

According to the views of the new organization Continental European interest in American zinc concentrates has now reached a stage of active inquiry for 1925 requirements. This development is due to the fact that in April, 1925, the Australian ore contract with the Belgian smelters will be terminated, at which time the Belgians may find it necessary to look elsewhere for ore, as it is expected that the Australian production henceforth will be diverted to Great Britain.

Trial shipments of Joplin ores have been made to Belgium for experimental purposes, and the tests have proved that Joplin ores are satisfactory to the Belgian smelters. It is now expected that the exports of American zinc to Belgium next year may reach a total in excess of 200,000 tons. Heretofore for many years zinc ore exports have been negligible, amounting in the last decade to a total of only 12,000 or 13,000 tons.

$2,000,000 for New Iron-ore Dock in Wisconsin

THE Great Northern Ry. Co. has announced the dismantling of its No. 1 dock, at Allouez, Wis., and the replacing of it with a dock on a concrete foundation and with steel network construction. The present dock is of wood, with 374 pockets of 300 tons each.

In rebuilding the present dock, an additional length of 724 ft. will be added, giving a total length of approximately 2,900 ft., which will increase the number of pockets to 524, with a total storage capacity of 180,000 tons. It is expected that this work will entail the expenditure of $2,000,000 and will be completed for the 1926 shipping season.

Program for Mining Congress Announced

Taxation, Tariff, Standardization, Problems of Gold and Silver Producers, and Other Topics Will Be Discussed

Announcement has been made of the more important features on the program of the twenty-seventh annual convention of the American Mining Congress to be held at Sacramento, Calif., Sept. 29 to Oct. 4. The formal opening of the National Exposition of Mines and Mining Equipment will take place on Monday evening, Sept. 29, in the Exposition Area opposite the State Capitol. On the following morning at the first general session of the convention, the topic "Needs of the Mining Industry" will be discussed. H. W. Seaman, president of the Mining Congress, will review the work of the organization in the last year. This will be followed by reviews of mining conditions in different districts by representative mining men.

Conferences will be held during the week on various topics. These, with the subjects of discussion and names of the principal speakers, will be as follows:

Federal Taxation

A. G. Mackenzie, Salt Lake City, presiding.

"Review of Changes in Federal Revenue Laws and Income Tax Procedure," McKinley W. Kriegh, chief of the Tax Division of the American Mining Congress.

"Taxability of Distributions by Mining Companies," Robert Buchanan, San Francisco, Calif.

"Treasury Regulations Governing Mining Inventories," T. O. McGrath, Bisbee, Ariz.

"Needed Changes in the Federal Revenue Law," A. E. Ramstedt, Wallace, Idaho.

Tariff

Jesse McDonald, president Colorado Metal Mining Association, presiding.

"Foreign Competition with American Industry," A. Cressy Morrison, New York City.

Standardization

"Elimination of Waste Through Standardization," C. B. Lakenan, Nevada Consolidated Copper Co.

"Applying Standards to Metal Mining," Stanly A. Easton, Bunker Hill & Sullivan Mining Co., Kellogg, Idaho.

"Possibilities for Metal Mining Standards," Charles A. Mitke, Bisbee, Ariz.

"Standardization of Coal Mining Methods and Equipment," Col. Warren R. Roberts, Chicago, Ill.

"Co-ordination of Mining Methods," E. A. Holbrooke, Pittsburgh, Pa.

Silver

The problems of silver producers will be discussed at a session on Friday, Oct. 3, the presiding officer being W. Mont Ferry, president of the American Silver Producers' Association, Salt Lake City.

At another conference, problems of gold producers will be considered, with W. J. Loring, of San Francisco, in the chair. Definite recommendations of a special committee will be taken up and discussed.

Conferences on taxation, coal, and oil shale are also included in the program.

"Government Invasion of Business" will be discussed at a conference on Thursday, with Franklin T. Griffith, of Seattle, in the chair. Addresses will be made by Norman Moray, vice-president of the Hartford Insurance Co., and J. F. Callbreath, secretary of the Mining Congress.

Louis S. Cates, vice-president of the Utah Copper Co., will deliver an address at a conference on Industrial Relationship. W. V. DeCamp, of the United Verde Copper Co., will also speak.

Other addresses on the program include one on the subject "Who Makes the Profit from Oil Production," by A. G. McLaughlin, president of the Chamber of Oil and Mines, Los Angeles, and one on the topic "Stabilization of the Mining Industry," by Robert E. Tally, general manager of the United Verde Copper Co.

Elaborate preparations have been made for the entertainment of the delegates in true Western style. There will be pageants and parades depicting the "days of '49." Whiskers of the period of 1849 will be the principal feature of these entertainments.

Bingo Plans Stimulate Mining in The Pas District in Manitoba

Gold mining prospects in The Pas district of Manitoba have been stimulated by the preparations of the Bingo Gold Mines, Ltd., of London, to establish a large milling plant and reduction works. The whole mining district is receiving the benefit of this project. The Manitoba Metals Mining Co., a subsidiary of the Mining Corporation of Canada, is rapidly developing the Rex, sinking shafts and pushing lateral work. The mill is operating steadily with a 25-ton output.

Three miles north of the Bingo group Joseph Myers has secured an option on the McCafferty properties. A shaft is down 28 ft., at which point the vein is wider than the shaft and shows much free gold. Many claims in the locality have recently changed hands.

The alleged discovery of platinum on the Mack property of Swan Olafson has aroused much interest, and samples have been sent to the Trail smelter for analysis.

Namiquipa Gets on Map

A district in Chihuahua, Mexico, that is attracting attention is Namiquipa. The town is more than 200 years old and was for a short time headquarters for General Pershing. Some mining was done there in the past, but recently Japanese continued old workings and encountered better ore. This has induced others to work, and they too have found ore than can be shipped. Ultimately the district will no doubt develop into a milling region, as prospective development indicates the possibility of a considerable production.

The veins are quartz in an eruptive rock. The region is favorably situated 30 miles from a railroad and in open country. Plenty of wood and water and a fine climate are assets.

Callow Process Used at Humboldt By United Verde

Experimental work conducted at the Humboldt mill, in Arizona, by the United Verde Copper Co. is said to be giving satisfactory results. It is said that a recovery of 97 per cent of the copper is being obtained. Five thousand tons more of schist ores will be shipped to the Humboldt experimental plant so as fully to test the process.

It was the original intention to ship a like amount of ore to the Inspiration plant, but this plan has been abandoned and the necessary equipment for testing the ores by the Callow process will be installed at Humboldt.

Hope for Some More Premiers in British Columbia

Dunwell Should Be Big Mine According to Reports of Development —Two Other Shippers—Big Missouri Re-bonded by New York Interests

THE Portland Canal district of British Columbia continues exceedingly active from the point of mining development. While the Premier is the only big shipper it should not be long before a number of other properties are sending out ore. During the last season there have been large investments in the development of properties which have as yet scarcely got beyond the prospect stage, but which are so promising that their future seems assured. George Clothier, the resident mining engineer, says that there had been much prospecting in the district, but that the outstanding feature of the season is the attention being given to exploration work on properties already staked.

In Victoria and Vancouver the northern mining enterprise which holds the spotlight is the Dunwell, and, if the reports being received regarding the extent and quality of new orebodies being opened are accurate, there can be no doubt that in this property British Columbia has another big producer. It is rather too early, however, to make any sweeping prophecies. Development so far undoubtedly is most encouraging.

In the course of a few months the road now under construction to the Dunwell mine will have been completed. The intention is that ore shall be shipped as soon as these transportation facilities are available.

Another Portland Canal property upon which attention has been centered is the Big Missouri, which has been through many vicissitudes in the course of its progress from a prospect to a producer. The latter point has not yet been reached, but all the old-timers of the North express confidence that perseverance in development will put this property among the great low-grade producing mines of the West. When the season opened the Big Missouri was in the hands of a syndicate controlled by Messrs. Trites and Wilson, who are heavily interested in the Premier mine. They, however, have allowed their bond to lapse, and now it is authentically reported that George Collins, representing New York interests, has taken over the bond, the new agreement calling for a total payment of $250,000.

The B. C. Silver Mines, Ltd., has made a shipment of high-grade ore approximating fifty tons and averaging, it is said, something better than $25 a ton. Some shipments have also been made from the Outsider. It may be said therefore that there are now three shippers in the Portland Canal district, —although the Premier is the only substantial producer.

High-grade ore is reported to have been discovered in the Silver Crest mine, in the Salmon River valley. The Independence mine, which is being developed by Victoria men and which is situated 12 miles from the mouth of the Salmon River, is showing up well. A body of galena ore 25 ft. wide has been uncovered. It carries values in gold and silver. The old Portland Canal mine also has been under development this season. It is not possible as yet to report results, but those who have been identified with the work appear to feel that it should be continued.

Colorado River Water and Power Compact Divides Arizona

Issue in Coming Gubernatorial Race—Copper Companies Advocate Ratification—Billion Annual Income

An outstanding issue in the Arizona gubernatorial race this fall is the "Colorado Compact." In 1921 Congress empowered Colorado, Wyoming, Utah, New Mexico, Nevada, California, and Arizona to form a compact for the allocation of the waters of the Colorado River among these states. The pact agreed upon by the representatives of the different states did not apportion the waters among the states, but divided the river valley into two basins, designating the first four of the above-named states as the upper basin states and the other three as the lower basin states. The water was divided on basis of 47 per cent to the upper basin and 53 per cent to the lower basin.

It is estimated that the power which could be developed from the construction of dams along the river would have an annual retail value of $600,000,000 and that the annual value of the water which could be stored in the reservoirs and used for irrigation would be $400,000,000. The pact has been ratified by the legislatures of all the states except Arizona.

Public sentiment, as represented in the present campaign by the Democratic Party, is opposed to the pact, on the ground that it does not secure for Arizona her fair share of the benefits which will accure from the utilization of dam sites along the river. All of the best dam sites lie in Arizona or along her boundary, but the principal market for power is in California. The latter state would also receive the greatest benefit from the storage of water for irrigation in the reservoirs created by the dams.

The Republicans, which, in general, include those operating the copper-mining companies, favor ratification of the pact, but with reservations. They wish by these reservations, or by a supplemental agreement among the lower basin states, to reserve the right to Arizona to tax power produced in Arizona or along her boundary but consumed outside the state. They also wish to reserve to Arizona the waters of Arizona tributaries to the Colorado as well as a part of the water of the main stream.

Sulphur Proves To Be Remarkably Efficient Fertilizer

Sulphur has a fertilizing action in excess of that heretofore thought to be the case, in the opinion of those who have conducted extensive experiments with it in France. It is claimed that the use of sulphur in the soils has resulted in substantial increase in the yields of potatoes, tomatoes, turnips, and garden truck generally. In one set of experiments the yield of the potatoes was increased 15 per cent and that of turnips 30 per cent. It has been found that sulphur increases the starch content of vegetables and promotes vigorous foliation. The sulphur is added to the soil in the autumn, as it breaks down gradually.

Concession Provides for $500,000 Concentrator at San Luis Potosi

AN IMPORTANT concession has been granted to the Compañia Metalurgica National by the government of the State of San Luis Potosi, Mexico. It provides for the construction by that company of a concentrator at San Luis Potosi with a daily capacity of 400 tons of ore. The proposed plant will cost, according to the terms of the concession, not less than $500,000, United States currency. It is to be finished within two years and will give employment to about 1,000 men.

The material and equipment for the construction of the plant may be imported duty free and the industry is exempt from state taxes for a period of ten years. It is believed by mining men familiar with the district that the construction of this ore-concentrating plant will do much to stimulate the industry around San Luis Potosi.

Mexican Mining Activity Greatest in Fourteen Years, Is Opinion

Revival of mining in the Pachuca district and in other localities of the same part of Mexico, including El Oro, is regarded in industrial circles as good evidence of a restoration of confidence in the stability of the government. It is stated that mining operations at Pachuca are now more extensive than at any time during the last fourteen years. The larger companies, especially the San Rafael y Anexas Mining Co., the San Jose de Pachuca Mining Co. and the El Oro Mining & Railway Co., are carrying out extensive plans of development upon their respective properties.

In the San Jose, the Refugio, and the Virginia mines of the San Jose de Pachuca Mining Co., large orebodies were recently encountered, adding considerably to the production of that company. During the three months ending June 30, 1924, the San Rafael y Anexas Mining Co. treated in its reduction mill 36,321 tons of ore, against 32,642 in the preceding quarter, showing an increase of 3,679 tons. Silver shipped during the second quarter was 15,413 kg., and gold 56,354 kg. both being in excess of production during the first three month of this year.

Utah Delaware, Née Utah Con., Mines 550 Tons Daily

The Utah Delaware—formerly the Utah Consolidated—of Bingham, Utah, has since April been operating at the rate of about 550 tons daily, or at about half capacity. This company ships its ore to its mill at Tooele, the concentrate going to the International smelter at that place. The grade of the ore is low and at present prices curtailment in the production of the property is held to be advisable.

Two Lose Lives in Unusual Mine Fire at Butte

Engineer Spills Gasoline at Hoist—Engine Room and Headframe Burn

In what was considered one of the most unusual mine fires on record, two Butte miners, Arthur King and Monte Allen, lost their lives on the morning of Sept. 3 at the Seymor lease, one of the old silver properties in the west end of the Butte mining district, near the well-known Nettie mine.

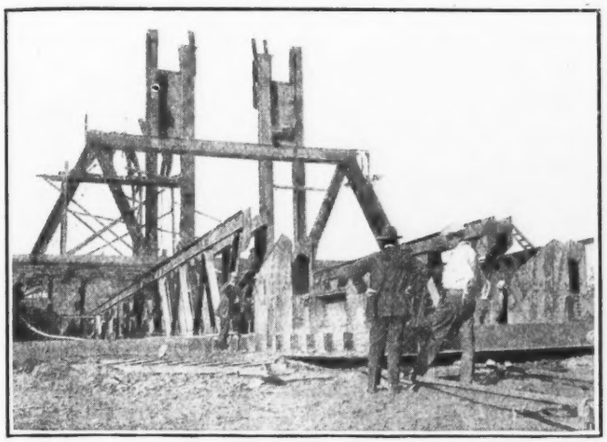
A. D. Rabizzoni, hoisting engineer, was filling the tank of the gasolene enbine, and the gasolene ran over the top of tank. It is presumed that the fumes came in contact with the flame of a kerosene lamp that was in use at the time. Immediately the hoist building was in flames, and the fire quickly spread to the wooden headframe and shaft timbers. Arthur King, John King, and Monte Allen were working in the mine at the time, and as soon as they smelled the smoke they hurried to the station, and upon looking at the shaft realized their predicament. They decided to climb out, and the three climbed until they were halted by the burning shaft timbers. One of them, fearing that their engineer was trapped in the hoist-room fire, decided to climb through the burning shaft at any cost in an endeavor to aid him, and managed to do so, but was frightfully burned. His two partners climbed back down to the 50 ft. level where they perished from smoke and gas. John King, a brother of Arthur King, escaped.

The engineer hurried to the nearest mine for assistance as soon as the fire started, and a fire-fighting and helmet crew were on hand as quickly as possible, but the men men could not be saved.

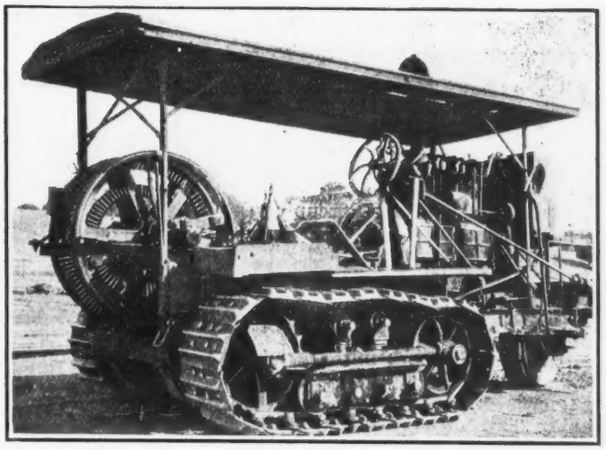
Ship Gold-Arsenic Concentrate from Nova Scotia

A steamer recently left Halifax, N. S., with a cargo containing one thousand tons of gold-arsenic concentrates, the first shipment of this kind, of any volume, to be made from Canada. The consignment, purchased from the Clark Gold Mines Corporation by a private English concern for the British Government, was bound for Antwerp, Belgium, and is to be used in connection with a new English process in the manufacture of dyes, for which the British Government has erected a plant at that point. The material which went to make up this first consignment was gathered from the Montague, Waverley, and other mines of this province, and the shipment is expected to be the forerunner of others.

The syndicate responsible for reopening the Montague mine and making the preliminary export purposes to take over and work a number of other old gold-mining properties in the territory served by the Dominion Atlantic Railway. It is estimated that 110,000 tons of arsenical gold ore is available in old mine dumps. The Clark Gold Mines Corporation, owners of the Canadian rights of a new concentrating process, has begun to treat these dumps.



All-steel dredge-hull in the process of dismantling



Tractor used by the Natomas Co. in dismantling No. 10 dredge

Iron-ore Shipments May Not Exceed 40,000,000 Tons

Iron-ore shipments from the Lake Superior district for the month of August were 6,689,564 tons, giving a total for the season of 28,796,703 tons. The shipments for this year in comparison with the 1923 season show a monthly decrease which to date has reached a total of 8,096,064 tons.

It is apparent that conditions have improved in the iron and steel business, but it is a question whether the reaction will effect this year's tonnage. If, as appears probable, the shipments continue at the present scale, the total for the season will be approximately 40,000,000 tons.

Underwriters Land Co. Options Waxahachie Property

The Underwriters Land Co. has taken an option on the Waxahachie mine and lease, a short distance to the south and east of the Underwriters mines No. 1 and No. 4. There are four shafts on the lease, and a mill that was built a number of years ago and will require considerable repairing. The property is at Quapaw, Okla.

The controlling interest in the Underwriters Co., which was owned originally by the late George H. Wormington, of Cleveland, has been sold to J. B. Swift, of Cincinnati, whose brother is president of the Eagle-Picher Lead Co.

Silver Shield Gets Control of Independence Property

The Silver Shield Mining Co., which two years ago transferred its interests in the Bingham district of Utah to the Bingham Galena Mining Co., reports the acquisition of the control of the Independence Mining Co. in the Tintic district. The management reports the property to be equipped with a bunk house, a blacksmith shop and a shaft-house.

There is an electrically driven hoist and motor on the property. It is proposed to sink the shaft—now down 413 ft.—to the 1,000 level, where drifting will be started. The Silver Shield has levied an assessment of 1c. a share.

Natomas Company of California Re-erects No. 10 Gold Dredge

The Natomas Company of California is dismantling its No. 10 dredge near Folsom, Calif., and is re-erecting it at a point 9 miles away from its present position. The dredge is one of the first all-steel dredges of large size and was put in operation in the fall of 1912. After twelve years of service the hull, superstructure, and machinery are in excellent condition. The ground having been worked out in its vicinity, it was decided to place the dredge upon a new area. All of the machinery was stripped from the hull, and two heavy steel cables and accessory tackle were used to haul the hull up onto a smooth sloping surface prepared on one side of the pond. Dismantling of the hull began, the parts being handled by a boom der rick. As dismantling proceeded, the hull was hauled out of the pond in stages. The machinery and parts are being transported in trains of wagons to the new site.

At the erection site a dredge pond has been excavated and a foundation prepared. The erecting plant consists of a machine shop, blacksmith and plate shop and living quarters. A boom derrick commands the erection site and is used for unloading the wagons and handling the parts in erection.

Dismantling of the hull and construction of the new dredge are proceeding simultaneously.

Tamarack Dredge Spells C. & H. Boat, Now in Dry Dock

The dredge built for Calumet & Hecla's new Tamarack reclamation plant, in the Michigan copper country, is doing duty temporarily at the Calumet reclamation plant while repairs are being made to the Calumet dredge. The new dredge is smaller but more modern and efficient. The old dredge, which has been in service more than ten years, is in drydock at Point Mills for overhauling.

The Tamarack plant is near completion, and its operation before the first of January next is confidently expected by the company officials.

Site of the re-erecting of the Natomas dredge in California

Porcupine Davidson Officials Involved in Seeming Fraud

Alleged that Wilfull Misrepresentation Effected Sale — New Examination Reveals $3 Ore, Not $11

Suits for damage and criminal action for fraud are likely to follow the recent annual meeting of the Porcupine Davidson company, operating in Ontario. The new board has issued a circular to the shareholders in which it is stated that the property has recently been reported on by R. H. P. Bullen, of the Mysore Mines, in India, and H. A. Kee, manager of the Kerr Lake mine, at Cobalt, and that the report of these engineers shows the mine to be unpayable. This, of course, is in direct contradiction to the reports of Messrs. Bent, Loring, and Fielding, on which the property was sold, their reports showing ore reserves with a gross value running into millions and an average grade of over $11. It is understood that the report of Messrs. Bullen and Kee shows an average of less than $3. The circular also makes a direct implication of fraud when it states that the directors now learn that at the time the property was sold, the vendor had assay plans confirming the results of Messrs. Bullen and Kee.

The Davidson property is in the Porcupine district and was one of the early discoveries in the camp. It went through several reorganizations and was finally taken over by the Davidson Consolidated. Reports were obtained from the three engineers mentioned and negotiations entered into for the sale of the property to Mitchelson Partners, Ltd., of London. A new company called the Porcupine Davidson was formed and an issue of shares put out on the London market. The issue, however, was not a success, so Mitchelson Partners paid to the Davidson Consolidated £113,000 to complete the terms of the agreement, on the understanding that the Davidson Consolidated would lend this sum to the Porcupine Davidson for a period of two years in order to develop and equip the property. As the time for repayment drew near negotiations were entered into for partial repayment and refunding of the loan, but before paying over any further money a re-examination of the mine was considered imperative. This examination has recently been completed, with the unfortunate results mentioned above, although it only serves to confirm the opinion generally held by mining men throughout the country. It is now understood that the repayment of the loan will not be made, and that this may be followed by action for fraud and misrepresentation as well as a criminal action.

Franklin Will Have Larger Hoist

A larger hoist is about to be installed at Franklin's new exploratory shaft, in the Michigan copper district. The shaft, which is being sunk to investigate the Kearsarge lode, is still in overburden, but is within 40 ft. of vein rock. Progress has been slow, on account of an excess of water. Once the lode has been reached, sinking will proceed at a more rapid rate.

Mexican Smelter Workers on Border Prefer South Side

MEXICANS working at the smelters in Douglas and residing in Agua Prieta, and those living at Naco and working at the Copper Queen concentrator, will be given permission to cross the international line at any time of the day or night, according to a ruling made by Charles Fowler, customs collector for Arizona. The new ruling was made following an appeal made by the Douglas smeltermen, more than 150 of whom live across the line and who when on the afternoon shift were compelled to wait around several hours before they could reach home. The cost of living is said to be cheaper south of the line and another attraction is the society of King Bacchus.

Dome Heads $8.58 Per Ton

During August the Dome Mines of Porcupine, Ont., treated 43,000 tons of ore and recovered $369,032, compared with $362,000 in July. Tonnage was somewhat higher and the grade was $8.58 per ton.

Kafue No. 1 Dredge Launched in Cariboo, B. C.

The Kafue Copper Development Co. launched the hull for its new dredge, Kafue No. 1, on Antler Creek, in the Cariboo mining division of British Columbia, on Aug. 22. The hull is 104 ft. long, 38 ft. wide, and 7½ ft. deep, and was built of local timber that was cut by the company. Work on the superstructure and the installation of machinery has been started, and, barring the unforeseen, the dredge should be in operation by the end of October, which should leave ample time for a trial run before winter begins. The dredge is being constructed by the Union Construction Co., of San Francisco.

The Kafue company has outlined a large area of ground with a Keystone drill on Antler and Cunningham Pass Creeks that will average 31c. per cubic yard.

Panhandle Asbestos Co. Gets Machinery in Idaho

The Panhandle Asbestos Co., operating near Kamiah, Idaho, has just received a carload of specially constructed machinery for the new plant situated at the mine. The asbestos deposit is about 200 ft. in length and 40 ft. wide, and stands 35 ft. above ground. The ore is said to be unusually rich.

Locally, the deposit has been divided into two classes, brown and gray. Some of the uses to which the ground material will be put are the manufacturing of paints and plasters, as fillers for cements such as magnesite, cement for flooring and paving, and high-temperature bricks.

American Flag, Park City, Utah, May Be Foreclosed

Silver King Coalition Involved—Purchased Lief Erickson Claim— Bonds Total $150,000

The American Flag Mining Co., which owns mining property at Park City, Utah, is being sued by the Utah Savings & Trust Co., which is seeking to establish a trust deed and first-lien foreclosure mortgage, and to recover $150,000 with interest. Defendants include the American Flag Mining Co., a Nevada corporation; George Rathman, receiver; the American Flag Mining Co., a West Virginia corporation; Silver King Coalition Mines Co.; Utah Power & Light Co.; Park City Mining & Smelting Co.; Park City Mines Co., and others.

The American Flag ground is well located in the Park City district, and has produced silver-lead ore from its fissure system. It has not been working for some time. The American Flag company was first organized as a West Virginia corporation, and later merged into the American Flag Mining Co., a Nevada corporation. The second company, the complaint states, failed to pay its annual license tax in Utah, and forfeited its charter in Utah. A trust deed was executed by the corporation first formed, to the Utah Savings and Trust Co. in 1908, for the purpose of securing 100 first-mortgage bonds of $1,000 denomination each, and 100 of $500, and the deed was conveyed to secure payment of bonds and interest. The bonds, payable in September, 1918, were sold and delivered, and are now outstanding. Through failure to pay, it is stated, the conditions of the trust deed have been breached, and the right has accrued to the plaintiff to foreclose the mortgage.

The Silver King Coalition Mines Co. is brought into the question through the Lief Erickson Lot No. 3 claim of the American Flag, which it acquired by quit-claim deed from P. J. Fallon, who acquired it, according to statement, on account of tax sale. The plaintiff asserts these deeds to be void, claiming that the sale for delinquent taxes was not conducted in a legal manner and that the certificate of sale was not lawfully made.

Mineral Basin Copper Co. Has Good Copper Prospect

The Mineral Basin Copper Co. is prospecting and developing a 500-acre tract of land on the west slope of the Pinal Mountains between Globe and Ray, Ariz. No. 2 tunnel, now in 225 ft., has drifted on a 3-ft. vein of ore for 120 ft. A 12-in. stringer in the vein assays 13.73 per cent copper, 10.8 oz. silver, and 0.1 oz. gold, and over its full width the vein averages more than 3½ per cent copper.

A station is being cut at the end of the tunnel preparatory to sinking a shaft to undercut the ore. The vein on the surface has been traced for 3,000 ft. The plan is to hand-sort and ship higher-grade ore to assist in financing operations. O. F. Beutke is manager for the company and Joseph Irving is consulting engineer.

Washington News

By Paul Wooton
Special Correspondent

Important Work of U. S. Geological Survey Hampered

Lack of Funds and Salary Increases Make Curtailment Necessary—No Money for Printing

As a result of the increased draft on its appropriations occasioned by the salary increases carried in the reclassification act, it has been necessary for the U. S. Geological Survey to discontinue some of its work. The mineral resources division has dropped its schedules on gems and precious stones and on mineral waters. Each of the other divisions has made corresponding reductions in the work which it has been doing.

Owing to the fact that the cement manufacturers have discontinued the compilation of their distribution figures, it has been necessary for the Survey to undertake to furnish the public with that essential information. It is expected that the August figures covering distribution will be ready to distribute with the production figures for September. As the Portland Cement Association has not been compiling these figures for a year, the Survey is attempting to gather the data for the back months as well, so as to fill in the gap in these statistics.

Despite the increased costs of travel and other expenses, and the augmented payroll, the Survey has less to spend than it had four years ago. The technical character of the service performed by the Geological Survey is lacking in any spectacular feature which would appeal to members of Congress generally. Some Senators and some Representatives, of course, have a keen appreciation of the value of geological work, of mapping and of statistics of mineral production. There is every reason to believe, however, that mining and other industries interested in the work of the Geological Survey and of the Bureau of Mines must manifest more interest in these activities if there are to be increases in appropriations. Just at this time, for instance, the Geological Survey is not able to fill the vacancies created by the resignation of its copper and nonmetallic minerals specialists. Though this does not mean that the work on these two important subjects is being abandoned, it is being kept up by geologists who are specializing on other minerals. This work must be done in addition to assignments which already are heavy. The *esprit de corps* of staff of the Geological Survey, their willingness to work overtime, and the excellence of their administrative direction is all that has prevented a collapse in one of the most important of the government's activities.

Instead of having to reduce its activities, there is abundant evidence that the public would benefit by permitting the Survey to do work which cannot be undertaken without additional appropriations. For instance, there is insistent demand for a service such as would be performed by a specialist on the minerals which go into construction work. Strange as it may seem, there has been little technical work on such an important commodity as sand. There is a widespread demand for more work on the pegmatite minerals. The paint industry is calling for basic information on the pigment minerals and earths. There is the greatest need for more oil specialists. All of these needs could be met adequately by an annual expenditure of $25,000.

One of the most blighting effects of the political efforts to reduce government expenditures—most of which are aimed at the 3 per cent of total expenditures which are devoted to the so-called welfare services—is the reduction in the item for printing. In most instances this cut is on a par with that of the farmer who reduced his expenditures by abandoning the harvest after his crop had been planted and cultivated.

Nothing New in "Rediscovery" of this Lost Art

Since the recent newspaper story of the wonderful discovery of "the lost art of hardening copper" by an automobile mechanic and the immediate sale of the "secret" for an unbelievable sum (cash in hand), the U. S. Bureau of Standards has received numerous inquiries concerning this and similar processes. From a set of samples submitted by one person, undoubtedly prompted by the newspaper story referred to, a typical piece was selected for examination as an example of the line along which such "inventors" work. The chemical analysis showed the following results:

	Per Cent
Copper	91.7
Aluminum	7.8
Manganese	0.25
Lead	0.10
Iron—less than	0.10

It is evident from this that the "hardened copper" was merely an aluminum bronze—an alloy known for a good many years and having considerable use. In addition the attempt had been made to "stiffen" and harden the material by rolling. The result, however, was decidedly inferior to what would be considered even fair commercial practice.

In general it may be said that present-day metallurgists are quite familiar with the general means which may be used in hardening copper or other metals. Essentially they are chemical in nature (alloying additions) or physical (cold working) or combinations of these two methods.

War Minerals Relief

Four war mineral relief claims, totaling $8,035.75, have been awarded recently by the Commission. The largest claim was to the National Pyrites & Copper Co., of Birmingham, Ala., the amount being $5,582.35. Awards were as follows:

Alabama	
National Pyrites & Copper Co., Birmingham	$5,582.35
California	
John B. Siebert, Sanger	138.16
Oregon	
W. E. Gilmore, Kerby	344.89
Dailey and Casey, Selma	1,970.35

London Letter

By W. A. Doman
Special Correspondent

East Rand Proprietary Shareholders Get Too Many "Reports"

Storm Center on London Share Market —Income Taxes Bewilder Burma Mines People

London, Sept. 2—The East Rand Proprietary Mines still seems to be a kind of storm center from the control and share market point of view. Development news is given out officially; unofficially, some correspondent goes one better, so that innocent holders for investment cannot understand the position. It is said that a group of independent shareholders in South Africa are to have their own representative on the board. This does not seem comforting for the general investor or speculator, for news goes to various "houses" and to group representatives first, and to the great "milch cow" last. It is surprising how information is transmitted from persons "in the know" at Johannesburg to different parts of Great Britain, predicting a big rise in East Rand "Props"—which hitherto has failed to materialize.

As mentioned on a previous occasion, developments at the Transvaal Silver & Base Metals property have not borne out early expectations. Fortunately, Sir George Albu did not make an active market in the shares in London, as he might have done, and this fact disappointed investors; he preferred first to test the property. As at the eighth level in No. 1 mine the lode has narrowed and has lost in mineral, it has been decided to sink a borehole from the surface to intersect the lode at an approximate vertical depth of 1,500 ft., which is roughly 800 ft. below the present lowest level. The company has sufficient assets to continue this boring.

The construction of Takoradi Harbor, in the Gold Coast colony, is expected to give a stimulus to manganese mining. The harbor is to be equipped to handle 3,000 tons of manganese ore daily, the ore being exported to America or England for smelting. Manganese mining has hitherto been held up both by reason of high railway freights and the cost of lighterage at Seccondee. The first part of the harbor contract has been let to Sir Robert McAlpine & Sons for £1,700,000.

Owing to the immense amount of metal already proved in the mines of the Burma Corporation, the shares—which are in the denomination of rupees—have come into prominence as an investment purchase. Holders, however, are now finding that there is a snag in the income tax. Indian normal tax, Indian super-tax, and British tax, all have to be paid, and the number of official documents to be filled up is somewhat bewildering. It may pay a wealthy shareholder to go to the trouble of reclaiming, but some of the smaller holders are finding the matter more bother than it is worth. Operations at the property are moving slowly toward the attainment of the enlarged production program.

Johannesburg Letter

By John Watson
Special Correspondent

Rhodesian Government Will Assist Prospecting for Minerals

Appropriate £25,000 for the Purpose—Increase in Mineral Output of the Union

Johannesburg, Aug. 11 — The Rhodesian government has recently earmarked £25,000 to encourage the mining industry, chiefly to assist prospectors and small workers. Parts of the country have, so far, been merely scratched on the surface.

At present, much interest centers in chrome ore, of which large deposits occur in the Umvukwer district of Mashonaland. Vast areas of country have recently been pegged, and many small interests have begun developing. Buyers have been about, of late, and several properties are under option. In the Lomagundi district, chrome areas are also being pegged, and good assays of chrome ore have been obtained. It is a district of few roads and no railways; though there is a possibility that an extension from Sinoia will be constructed from the Salisbury-Sinoia line.

Mica, also, is being worked in the Lomagundi district. According to experts who have visited the Grand Parade mine, the mica there is of excellent quality.

The mineral production of the Union of South Africa, for the first half of 1924, shows an increase in value of more than £4,250,000, compared with the corresponding half of last year. Details are as follows:

	Jan.-June 1923	Jan.-June 1924
Gold (at increased value)	£19,937,346	£22,365,734
Silver	99,057	96,265
Diamonds	2,316,509	3,926,066
Osmiridium		36,320
Coal	1,810,224	1,858,746
Copper ore and concentrates	148,069	217,916
Tin concentrates and metallic	52,376	148,206
Other minerals	153,284	129,946
Total	£24,516,855	£28,779,199

The announcement of an initial dividend of 1s. per share, by the Zambesia Exploring Co., and the publication of a report of the Union Minière, showing copper ore reserves amounting to 72,000,000 tons, have made plain the vast potentialities of the Congo copper belt. These reserves are mainly contained in an area of 10 miles, whereas the whole copper belt, to be developed and worked by the Union Minière, extends for at least 250 miles.

The following crushing results for July, from the leading profit-earning gold mines of the Rand, have recently been published:

	Tons Crushed	Value or Revenue	Costs per Ton Milled	Estimated Profit
Government Areas	165,000	£338,120	16s. 7.8d.	£206,289
New Modder	124,000	252,310	17 3.3	145,198
Crown Mines	219,000	297,204	18 10.7	90,351
Van Ryn Deep	68,400	143,676	18 11.1	80,060
Modder Deep	45,200	110,517	16 0	74,329
City Deep	193,000	185,468	22 1.8	71,379
Springs	67,300	128,303	20 10.4	67,702
Modder B	68,000	125,024	18 8.0	61,566
Randfontein Estates	211,000	252,238	18 5.6	60,015
Brakpan	75,700	123,829	20 10.8	53,964
Geduld	71,000	114,534	18 6	48,856
Robinson Deep	74,500		17 11.0	45,548
New State Areas	70,000	114,378	21 4.0	40,008

Another Tunnel Record!

At No. 1 heading of Pit No. 3 tunnel of the Pacific Gas & Electric Co., on the Pit River, in northern California, an advance of 600 ft. was made during August, 1924. The tunnel is 23 ft. in diameter and was excavated and timbered over the foregoing length by three shifts, each of twenty-two men per day, within the month. Each shift consists of two shift bosses, eleven miners, eight muckers, and one operator of a mechanical shovel.

The rock encountered in this section of the tunnel was volcanic tuff, agglomerate, and seamy diorite. The 9,660 cu.yd. excavated (place measure) required 7,625 lb. of 40 per cent gelatin powder. The three shifts placed all the timbers. The only other men underground were the drivers of the storage-battery locomotives and the track men. The length of haul to the dump averaged 4,000 ft.

Ahumada Lead Declares Its Fourth Dividend

The Ahumada Lead Co., operating in the Los Lamentos mining district in Chihuahua, about a hundred miles south of El Paso, Tex., on July 31 declared a regular dividend of 7½c. and an extra dividend of 7½c., payable Oct. 2 to stockholders of record Sept. 15, 1924. This is the fourth quarterly dividend paid by this company since operations were started.

During the last year, all exploratory work in Ahumada ground has been favorable. A branch line, approximately 40 miles long, built by the company, connects the mining camp with the Mexican Central railroad. The mine produces a lead-silver ore of good grade which is shipped to the smelter in El Paso.

Two West Butte Companies Sink Development Shafts

A. M. Chisholm, president of the Butte-Midwest Mining Co., has announced that the Prospector shaft is to be sunk to the 800 level. The sinking and additional improvements contemplated will require an expenditure of approximately $200,000. Charles Elliott, vice-president, accompanied Mr. Chisholm on his recent trip of inspection. Both expressed themselves as being pleased with the present showing of the property.

The Butte-West Side Mining Co. is making good progress in sinking its Minnie-Jane shaft, and will soon have completed an increased depth of 200 ft. Mining operations have been hindered considerably, but an average of 50 tons of ore per day has been maintained.

Mexico City Letter

By W. L. Vail
Special Correspondent

Contradict Current Reports of Shutting Down Copper Mines

Mazapil Copper Co. Will Increase Output—New Income Tax Schedule Subject of Much Protest

Mexico City, Sept. 8—A number of erroneous statements have gone out recently regarding the situation of the principal copper camps in Mexico, some to the effect that there will be a general closing down on account of the low price of copper. All the big camps however, continue to work, and none of them, so far as can be learned, has any intention of shutting down. At Nacozari the Moctezuma Copper Co. is working at about 60 per cent of capacity, and at Cananea the Cananea Consolidated about 40 per cent. The big mines at Boleo, Lower California, have reduced their output somewhat, but the Mazapil Copper Co., operating in the State of Zacatecas, which has been making some modifications in the plant, is preparing to operate at the full capacity of the smelter. Most of the companies are taking advantage of the situation to do exploration and development work. The Department of Commerce and Labor estimates that despite unfavorable conditions, the 1924 output of copper will reach more than 23,000,000 pesos in value based on current prices.

The new income tax schedule went into effect on Aug. 1 and has created some confusion in mining, as well as other business circles. The various Chambers of Commerce of the country as well as the mining chambers continue to protest against the law and pronounce it unconstitutional and unworkable.

According to a decree of the Secretary of Commerce and Industry, mining agents are allowed to increase their fee for recording and transmitting applications for titles to new properties 50 per cent over the former charges. Mining engineers have pretty generally increased their charges for making surveys. The Federal Government also has attached an additional 10 per cent on the 10 pesos per claim (pertenencia) to be deposited for stamps on the titles when they are officially issued. This has made the expense connected with denouncing a claim considerably greater.

New regulations which will govern the mining laws of the country have been drafted by a special commission of engineers appointed for that purpose. The government complains that it has not been properly informed heretofore as to the production from mineral sources, and believes that under the new system the revenues will be materially increased. Heretofore, statements were only required from mine owners in cases of exportation of ores. Now statements will be required of mine production as well, and the system of taxation will be revised in a manner benecial to the revenue of the government.

Men You Should Know About

A. H. Brooks is in Anchorage, Alaska.

Ira B. Joralemon, mining engineer, recently returned to San Francisco from Ely, Nev.

George Young, of Cananea, is representing the Cananea Consolidated Copper Co. in Mexico City.

C. E. Dobbin and **J. B. Reeside, Jr.,** are engaged in geological work in the Denver basin.

K. F. Mather is in Washington for conference regarding his work in northeastern Colorado.

Sidney Paige has completed his season's field work and is again at his desk in Washington.

A. F. Buddington has completed his field work in southeastern Alaska and is en route to Washington.

F. P. Maclennan, general manager of the Miami Copper Co., has returned from a vacation spent on the Pacific Coast.

Charles Hardy, of Charles Hardy, Inc., New York City, who has been in Europe for two months, has returned to the United States.

Durand A. Hall, mining engineer, has returned to Berkeley, Calif., from a trip to the Bishop Creek district in Inyo County, Calif.

Edmund Jussen, mining engineer and geologist, has established headquarters with the Diamond Drilling Co., Rialto Building, San Francisco.

J. M. Callow, president of the General Engineering Co., sailed on Sept. 13 for a two months' business trip to London and the Continent.

T. W. Stanton has received the degree of doctor of science from the University of Colorado. He received his bachelor's degree from that institution in 1883.

Dwight E. Woodbridge, consulting mining engineer, is in St. Louis on professional business. He has just returned to Duluth from a sojourn in northern Canada.

Dr. Charles Schuchert, of Yale, has arranged to deliver a twelve weeks' course of lectures on advanced stratigraphy at the University of Arizona, during the coming year.

Alfred D. Flinn, director of the Engineering Foundation, has been made an honorary foreign member of the Masarykova Akademie Prace of Prague, by the Republic of Czechoslovakia.

R. T. Murrill, efficiency engineer with the Inspiration Consolidated Copper Co., has accepted a position in the operating department of the St. Joe Lead Co. He assumed his new duties about Sept. 15.

J. E. Spurr, editor in chief, and **A. B. Parsons,** assistant editor, *Engineering and Mining Journal-Press,* were members of a party of engineers that on Sept. 17 inspected the plant of the General Electric Co. at Schenectady, N. Y.

Dr. J. S. Flett, director of the Geological Survey of Great Britain, and several of his associates visited the U. S. Geological Survey and other scientific agencies in Washington last week.

H. G. Moulton, mining engineer, of New York City, was a recent visitor to the Superior district, where he was engaged in collecting statistical data. During his visit he was a guest of the Magma Copper Co.

Sir Robert Clough, of London, has returned from a visit to the Porcupine, Kirkland Lake and other gold areas of northern Ontario and anticipates increased interest in Canadian mining enterprises by British capitalists.

Edward H. Robie

Edward H. Robie, assistant editor, *Mining Journal-Press,* is making a field trip, in the course of which he will visit Butte, Jardine, and Great Falls, Mont.; Deadwood, S. D.; Omaha, Neb., and Chicago. He will return to New York early in October.

Nelson Littell, for several years an examiner in the metallurgical and chemical division of the Patent Office, has recently become a member of the firm of Hammond & Littell, patent lawyers, 110 East 42d St., New York City.

C. M. McKergow, professor of mechanical engineering, has been appointed by the Board of Governors of McGill University, Montreal, as a delegate to the International Petroleum Congress to be held at Tulsa, Okla., in October.

Ralph Arnold, George W. Starr, Alfred Harrell, W. P. Hammon, E. E. Paxton, C. S. Maltby, E. C. Hutchinson, V. A. Hart and **O. McCraney** were appointed along with others by Governor Richardson to represent California at the American Mining Congress convention at Sacramento, Calif.

Philip S. Smith and his party, who have been making geologic and topographic surveys in Naval Petroleum Reserve No. 4, on the Arctic coast of Alaska, left Nome Sept. 14 and are returning by way of the Yukon River and the Government Railroad. **S. R. Capps** sailed from Seward Sept. 7. **R. H. Sargent** left Ruby Sept. 13.

Claude Maitland has left for West Africa on behalf of the directors of Simpa Reefs, Ltd., to examine their area, which is 20 miles north of Axim. The property has been in the hands of speculators for some years, but so far little in the way of mining has been done. Native pits on the property are numerous, and it is said there are indications that ore of high gold content has been extracted in the past.

Roland T. Day, mining engineer, of New York, has returned from making an exhaustive examination of the tar sands of the McMurray area of Alberta, in the interests of capitalists who have large plants in the United States. He says that the McMurray field is the richest and the largest he has seen in the course of a wide experience, and that there appears to be no obstacle to their development for oil production.

M. Jacobson has been added to the staff of the Senate Commission of Gold and Silver Inquiry so as to expedite its investigation of the international monetary, currency and exchange situations. He will assist **Dr. John Parke Young,** who is in charge of the work. Mr. Jacobson has been statistician for the Federal Reserve Board for many years, and is particularly well equipped by his previous experience to assist in this part of the commission's work.

F. C. Worth, mining engineer, of Chicago, has returned from a visit to northern Ontario, where he has secured several properties in the Sudbury district in association with American capitalists. Some of the claims contain mispickle ore and others showings of platinum. Mr. Worth says that the mispickle deposits can be operated successfully by a new process of treatment, by which, in addition to the recovery of the gold and the arsenic, prussian blue can be produced on a commercial scale from the residue.

Obituary

A. G. Purchas, manager for eastern Canada of the Canadian Rock Drill Co., died in Cobalt on Sept. 6, following an auto accident in which the arteries of his arm were severed. Mr. Purchas was an Australian by birth and served three years overseas during the great war, part of the time at Gallipoli. He is survived by his widow.

J. V. Saddlier, who died at Melbourne, Victoria, Australia, in August last, at the age of seventy-nine years, at the time of his death was interested in the Ashcroft electrolytic process for recovering zinc from Broken Hill ores. He also took a leading part in the negotiations that ended in the purchase of the Central mine, in that field, as well as in the promotion of the Sulphide Corporation to work that mine and to exploit the Ashcroft process. As a contractor in a large way, Mr. Saddlier carried out the work of excavating the huge open cut on the Broken Hill Proprietary Co.'s mine, intended to relieve the pressure on the workings underneath.

New Machinery and Inventions

Rubber—Its Growing Importance in Metallurgical Industry

Ability to Withstand Abrasive and Corrosive Action as Well as Shock Makes It Useful for Lining Pumps and Grinding Mills, and for Other Purposes

RUBBER, in its various compounded forms, has peculiar properties which are not duplicated in metal, wood, or stone. Some of the more important of these will be outlined so that the reader can see the possibilities of rubber as a useful material in mining and metallurgical processes.

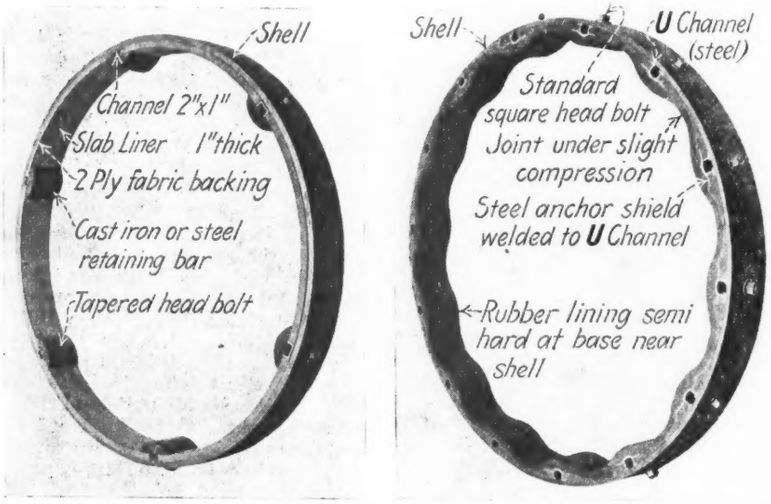
Probably the most important property of rubber is its elasticity and its ability to resume its original shape after compression and deflection. This same property gives rubber the ability to absorb shocks and to arrest vibration with a minimum of destructive action against the receiving medium. This resiliency is also the secret of the success of rubber to resist abrasion to a much greater degree than the hardest and toughest of alloy steels. The principle is that the abrading medium in motion impinging against the rubber indents the tough rubber, thereby stopping the force of the blow, without the surface of the rubber being punctured or destroyed to appreciable degree.

The homogeneous nature and absolutely amorphous structure of rubber and its compounds provides a material practically impervious to the penetration of liquids and gases. Certain inherent properties that it possesses make it an ideal material to resist many chemicals which have a decidedly corrosive action on wood and metals. The effectiveness of rubber as an insulation of electric current is well known.

Rubber, unlike metal, cannot be melted and poured to required shape, but, in its plastic, unvulcanized condition, it can be molded to shape by means of a metal mold and heated hydraulic press.

Rubber clothing, shoes, conveyor and transmission belting, gaskets and hose have long been recognized as necessities to carry on successful mining and milling operations. Wider application of rubber in the milling and mining processes has been made by some recent and revolutionary developments, conceived and sponsored by practical mill men and mining engineers, who have recognized the latent possibilities of the substance. Among the most notable of these recent developments are rubber-covered impellers for flotation cells, rubber liners and runners for centrifugal sand pumps, sheet rubber for launder and bin linings, a specially compounded rubber made in a heavy sheet and molded form for lining wet grinding ball mills, rod mills, and pebble mills, and a rubber bearing which will operate under water, or with water lubrication only. All of the above-mentioned articles have passed through the experimental stage, and practical applicability has been assured.

At one of the large Western copper concentrators, considerable trouble was experienced by the need of frequent replacement of flotation impellers. Abrasion of the pulp on the fast-revolving impeller kept the surface well scoured, and the corrosive action of the soluble acids in the ore combined to make short life of the iron impeller. Iron was replaced with bronze, which obviated the corrosive action, but there remained the abrasion on a material considerably more expensive than iron. Iron impellers covered by soft rubber were tried out with such successful results that the rubber-covered type superseded the metal types formerly used.



Left—Slab type rubber lining for ball mills mounted in 6-in. section of 5-ft. shell. Right—Wave-type rubber lining mounted in similar section

The abrasive and corrosive action in a centrifugal sand pump is present even to a greater extent because of higher velocity and larger size of the suspended grit. Pump casing linings made of soft rubber have shown remarkable resistance to abrasion, and, under the most severe operating conditions, the rubber-covered runners and casing liners possess a life many times that of steel parts made in similar shape and dimensions.

Bins, chutes, and launders, where abrasive tendency of the ore exists to a destructive degree, have been lined in makeshift fashion for many years with strips of old rubber belting. A demand from the field for sheet rubber for this purpose has stimulated the manufacture of a special grade to fulfill this need. Sheet rubber to resist abrasion and corrosion is also being used in flotation cells.

There has appeared before in these pages[1] a description of the application of rubber as an abrasion-resisting lining for rotary grinding mills. It is certainly a revelation when one learns by actual demonstration that a piece of specially compounded rubber 1 in. thick, weighing approximately 6 lb. per square foot, will outwear 3 in. of the hardest and toughest manganese steel, weighing 120 lb. per square foot. The principal claims for the rubber liner are: decreased transportation cost, decreased first cost, longer life and lessened slippage of balls; all of which tend toward a substantial reduction in grinding costs per ton of ore. A rubber ball mill lining, recently developed, has been thoroughly tried out and has been adopted by several of the large mining companies, as well as by cement and chemical concerns.

The rubber bearing consists of a metal shell or casing, split or preferably solid, lined with a tough rubber compound vulcanized to the metal shell. The rubber bearing surface is cut with a helical groove to insure proper lubrication by water. The original conception of the rubber bearing, by one of the prominent mining engineers in the West, was for the sole purpose of supplying a centrifugal sand pump with a bearing that would not be cut out rapidly by the grit in the pulp to be pumped. The bearing proved to be a complete success and soon found a wide application in centrifugal pumps and in drive shaft bearings in the marine field.

Metal bearings of the sleeve type have purposely been made of materials softer than the supported shaft, so that in case of cutting or scoring the bearing itself would be destroyed before the shaft is damaged. Grit entering any of these hard-faced bearings is imbedded in the bearing to the extent that the bearing itself becomes a matrix holding such grit against the shaft, and cutting and scoring results. The same grit entering a rubber bearing does not cut or score the shaft. The bearing surface, being of a soft rubber compound, yields under the pressure of the grit particle to such a degree that cutting is impossible. The grit is rolled across the surface of the bearing

[1] "Rubber Lining for Tube and Ball Mills," by Arthur B. Parsons, *E. & M. J.-R.*, Sept. 22, 1923.

by the rotation of the shaft until it reaches the helical groove, where it is carried away by the water.

The primary factor to be considered in the application of rubber bearings is to have the bearing totally immersed in water, or to have a constant supply of water flowing through the bearing to maintain a water film for lubrication.

The coefficient of friction between smooth metal and dry rubber is exceptionally high, but when a film of water is introduced between the two surfaces, the coefficient is reduced to less than that of an oiled babbitted bearing.

One of the common questions brought up in discussion of rubber bearings is as to the pressure which they will carry. Rubber bearings are working successfully under pressures up to 350 lb. per inch of projected area, which is considerably in excess of good practice with babbitt bearings. High speeds are not prohibitive, as rubber bearings have been operating satisfactorily at speeds up to 5,000 r.p.m.

Some rubber bearings have found their way into the mining industry in centrifugal pumps, but no industry affords so many tentative and ideal applications, a few of which are listed, and should be investigated by engineers:

1. Wet elevator boot-shaft bearings.
2. Wet trommel spider-shaft bearings.
3. Submerged bearings at terminal of bucket ladder of dredgers.
4. Log washer paddle-shaft bearings.
5. Flotation impeller-shaft bearings.
6. Drag classifier bearings.

All of the above-mentioned applications bring the bearing in close contact with gritty pulp which has caused considerable damage in the metal shaft bearings now employed. Such applications that are not entirely submerged in water or pulp can be conveniently piped to provide the required water for lubrication.

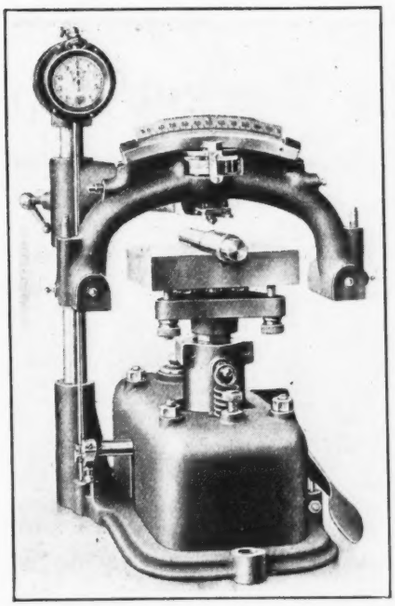
Two New Hardness Testers

The accompanying photographs show two new developments of the pendulum hardness tester which Edward G. Herbert, Ltd., of Manchester, England, is now exhibiting in the Machine Tool Trade Exhibition in London. These are the standard 4-kg. pendulum hardness tester and the 24-kg. pendulum hardness tester.

In the standard 4-kg. pendulum hardness tester the pendulum operating stand is specially adapted for inspection testing where a large number of tests must be effected rapidly. It also enables "time tests" to be made without previous practice. The standard pendulum is used, and the operation is entirely mechanical. Slight movements of the one handle serve to release the table and allow it to rise until the pendulum swings gently on the work; to operate the stop watch; and to lower the table and replace the pendulum on its three-point support. The arm supporting the pendulum can be raised to admit specimens up to 6 in. deep.

A ball-pointed diamond can be supplied for inspection testing on hardened steels.

The table is mounted on a plate which rests on three leveling screws. It can be replaced by special fixtures for testing irregularly shaped work when necessary.



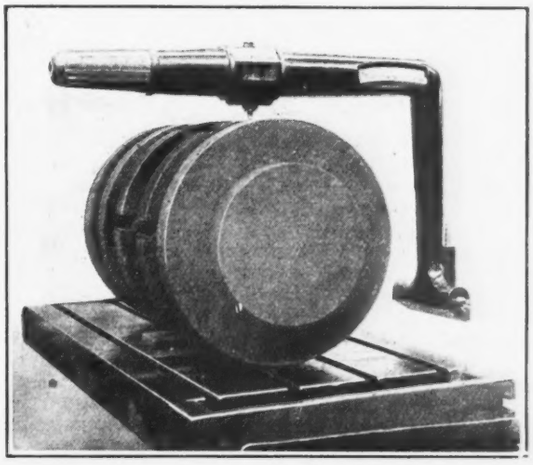
Standard 4-kg. hardness tester

The standard pendulum can be used to make time tests on this stand and also to make "scale," "work-hardening" and temperature tests by hand operation.

The 24-kg. pendulum hardness tester is identical in principle with the standard 4-kg. pendulum, but is adapted for testing very large work. With it, hardness tests can be made on shafts or rolls up to 30 in. in diameter; at any point on plates or other flat surfaces 30 in. wide; at any point on the face of gears or drums of any diameter and 30 in. wide; and inside a hole such as the bore of a gun or a large bearing.

The pendulum weighs 24 kg. and is pivoted on a steel ball three millimeters in diameter. Adjustable weights are provided whereby the center of gravity of the pendulum can be brought to the centre of the ball, and a central weight mounted on a micrometer screw provides for adjusting the length of the pendulum.

The 24-kg. pendulum hardness tester, shown here, is adapted for making time tests for indentation hardness, scale tests for work-hardness, and for measuring the work hardening capacity of metals.



Trade Catalogs

Blowers—The American Blower Co., Detroit, Mich., has issued bulletin No. 1,103, describing the American H. S. fans. The 36 pages of the catalog contain many illustrations describing the construction and operation of these high-speed fans as well as numerous tables of capacity data.

Hammer Drill—The new Model 37 Turbro Waughammer is described in a new 16-page illustrated pamphlet issued by the Denver Rock Drill Manufacturing Co., Denver, Colo. In addition, brief descriptions of the Model 337 Turbro drifter and other drifting machines are included, as well as miscellaneous specialties made by the manufacturer.

Mine Car Lubrication—The Lincoln greasing system for mine cars, a high-pressure greasing system, the essential feature of which is the Lincoln automatic greasing machine, is described in an 8-page illustrated pamphlet recently issued by the Lincoln Steel & Forge Co., St. Louis, Mo.

Crushers—A new bulletin, No. 261-D, descriptive of the Telsmith primary breaker and the Telsmith reduction crusher, is being distributed by the Smith Engineering Works, Milwaukee, Wis.

Elevator Equipment—Electric elevator control equipment is covered in detail in publication No. 3,082, issued by the Cutler-Hammer Manufacturing Co., 30 Church St., New York City.

Stokers—The third edition of Catalog L has just been received from the Illinois Stoker Co., Alton, Ill., in which is contained a complete discussion of both the Type A (natural draft) and Type G (forced draft) Illinois chain grate stokers. A feature of the catalog is a number of full-page blueprint drawings which illustrate the use of both of these types of stokers in connection with all of the principal types and makes of boilers.

Timber Treating—The Century Wood Preserving Co., Century Building, Pittsburgh, Pa., has prepared a data sheet entitled "Costs of Treating Cross Ties," in which it discusses the question of what treatments are most economical. This pamphlet contains eight pages and will be of interest to mining companies.

The Market Report

Daily Prices of Metals

Sept.	Copper, N. Y. net refinery	Tin		Lead		Zinc
	Electrolytic	99 Per Cent	Straits	N. Y.	St. L.	St. L.
11	13.00@13.125	50.375	50.875	8.00	7.875@7.90	6.25
12	13.00@13.125	49.625	50.125	8.00	7.90	6.225@6.25
13	13.00	49.375	49.875	8.00	7.90	6.225@6.25
15	12.875@13.00	48.375	48.875	8.00	7.95	6.225@6.25
16	12.875	46.50	47.00	8.00	7.90	6.15 @6.20
17	12.75@12.875	47.00	47.50	8.00	7.875	6.15@6.175
Av.	12.958	48.542	49.042	8.00	7.902	6.217

*These prices correspond to the following quotations for copper delivered: Sept. 11, 13.25c.@13.375c.; 12th, 13.25c.@13.375c.; 13th, 13.25c.; 15th, 13.125c.@13.25c.; 16th, 13.125c.; 17th, 13.00c.@13.125c.

The above quotations are our appraisal of the average of the major markets based generally on sales as made and reported by producers and agencies, and represent to the best of our judgment the prevailing values of the metals for deliveries constituting the major markets, reduced to the basis of New York cash, except where St. Louis is the normal basing point, or as otherwise noted. All prices are in cents per pound. Copper is commonly sold "delivered," which means that the seller pays the freight from the refinery to the buyer's destination.

Quotations for copper are for ordinary forms of wire bars, ingot bars and cakes. For ingots an extra of 0.05c. per lb. is charged and there are other extras for other shapes. Cathodes are sold at a discount of 0.125c. per lb.

Quotations for zinc are for ordinary Prime Western brands. Quotations for lead reflect prices obtained for common lead, and do not include grades on which a premium is asked.

The quotations are arrived at by a committee consisting of the market editors of *Engineering and Mining Journal-Press* and a special representative of the Bureau of Mines and the Bureau of Foreign and Domestic Commerce.

London

Sept.	Copper			Tin		Lead		Zinc	
	Standard		Electrolytic						
	Spot	3M		Spot	3M	Spot	3M	Spot	3M
11	63	64 1/8	67 3/4	252 3/8	254	33 1/4	32 3/8	33 1/8	33
12	63 1/4	64 1/4	67 3/4	249 1/4	251	33 1/4	32 1/2	33 1/4	33
15	62 3/4	63 3/4	67 1/4	240 3/4	242 3/4	33 1/8	32 3/8	33 3/8	33
16	62	63	66 1/2	231 3/4	234	32 1/2	32	33 1/4	32 7/8
17	62 3/8	63 3/8	66 1/2	232 1/2	234 3/4	32 5/8	32 1/8	32 7/8	32 5/8

The above table gives the closing quotations on the London Metal Exchange. All prices in pounds sterling per ton of 2,240 lb.

Silver, Gold, and Sterling Exchange

Sept.	Sterling Exchange "Checks"	Silver		Gold London	Sept.	Sterling Exchange "Checks"	Silver		Gold London
		New York*	London				New York	London	
11	4.45 1/8	69 3/8	34 15/16	92s 10d	15	4.45 1/2	69 3/8	34 13/16	92s07d
12	4.45 3/8	69 1/8	34 3/4	92s 07d	16	4.46	69 1/2	34 15/16	92s08d
13	4.46 1/4	69 1/4	34 13/16	.. ...	17	4.47 1/2	69 3/4	34 15/16	92s05d

New York quotations are as reported by Handy & Harman and are in cents per troy ounce of bar silver, 999 fine. London silver quotations are in pence per troy ounce of sterling silver, 925 fine. Sterling quotations represent the demand market in the forenoon. Cables command one-quarter of a cent premium.

Metal Markets Generally Weaker

New York, Sept. 17, 1924—The decline in the London price of tin and copper unsettled confidence in the course of these two metals here, both of them falling almost daily. Zinc has also become easier, but the position of lead remains strong, although sales for the week have been light in that metal. Silver is 69⅜c. today—the highest price since the fall of 1922.

Copper Slides Back

Although sales of copper for the week have been only moderate in amount, consumers have manifested a keen interest in the market. Six of the largest manufacturers, chiefly wire and brass companies, have been following prices closely in the last two days, especially yesterday, when the market took a rather severe tumble—to 13¼c. delivered. Today a fair sized quantity was sold for 13c.—the quotation of several producers. It would not be surprising to see consumers purchase heavily near or at the present level, especially as they have been out of the market for more than two weeks. The earlier part of the week was quiet, fair-sized tonnages only being sold at from 13¼ to 13⅜c., but after tin took its precipitate decline the market became distinctly softer, and producers had trouble making sales even at pronounced concessions. Those producers who were not very active in the domestic market pressed their metal for sale abroad, with the consequence that much price cutting occurred. Germany has been the best customer in Europe for the week.

Lead Market Steady

The official contract price of the American Smelting & Refining Co. continues at 8c., New York.

There has been a fairly good demand for lead. Although consumers have not bought heavily, producers have not pressed any metal for sale. In New York the great bulk of the business was done at 8c., with one producer obtaining 8.25c. for a lot sold last Thursday. The metal was sold at 8c. every day of the week, however. In St. Louis prices moved slightly upward and then declined gracefully to where they started. This was caused by speculative buying and selling—profit taking occurred after the market touched 7.95c. Today lead can readily be procured in the West on a 7.875c. basis. The market seems hesitant. October lead is still available in good-sized quantities. It is noticeable that the spread between the London and New York market at present is about normal, whereas a few weeks ago the spread was narrower than it should be. Producers would like to see the market steady, but have insufficient quantities of lead in stock to help iron out the irregularities of the market.

Zinc Sold at 6.15c.

Galvanizers have been moderately interested in the Prime Western zinc market. Sales were made by producers generally only after giving decided shading to their quotations. More than 1,000 tons was sold today at 6.15c. for delivery in October and November. The market was strongest on Monday, when slabs were sold for 6.225 to 6.25c. per lb. St. Louis. A small tonnage was bought by consumers abroad. The statistics of the American Zinc Institute for August show a decrease in stocks of about 1,800 tons. Stock on Aug. 1 was 52,705; production for August, 41,775; shipments, 43,558; stock Aug. 31, 50,922 tons. High-grade zinc continues to be sold for 8@8¼c. delivered.

Tin Declines 2½c. in a Week

The withdrawal of speculative support from the London tin market caused prices to drop £30 during the week, with corresponding declines here. Consumers seem to have been attracted by the low price of 47c. per lb. for Straits tin yesterday, for buying was unusually heavy. Purchases were large today also, indicating that tin-plate manufacturers are anxious to cover their requirements at present prices. Arrivals of tin in long tons up to and including Sept. 15 were 3,135 tons.

Silver Firm and Higher

The market continues firm with a new high quotation in New York of 69⅜c. on Sept. 17. China rates have improved and the Indian bazaars are better buyers at the higher level.

Mexican Dollars—Sept. 11th, 53⅜c.; 12th, 53½; 13th, 53¼; 15th, 53⅜; 16th, 53½; 17th, 53⅜.

Circulation Statement

A statement issued by the U. S. Treasury Department showing the amount of money in circulation in the United States on Sept. 1 follows:

Gold coin and bullion	$4,531,150,497
Gold certificates	1,283,202,299
Standard silver dollars	504,944,851
Silver certificates	416,065,498
Treasury notes of 1890	1,416,626
Subsidiary silver	277,109,790
United States notes	346,681,016
Federal Reserve notes	2,229,499,680
Federal Reserve bank notes	9,794,170
National bank notes	777,193,194
Total Sept. 1, 1924	$8,676,373,198

Exchanges Slightly Higher

On Tuesday, Sept. 16, the exchanges closed higher and firmer in a quiet market. Francs were 5.34c., lire, 4.375c. and Canadian funds in New York ⅛ per cent discount.

Other Metals

Quotations cover large wholesale lots unless otherwise specified.

Aluminum—99 per cent grade, 28c. per lb.; 98 per cent, 27c. London, £125 per long ton.

Antimony—Per lb.:
Chinese brands, 11@11¼c.
W. C. C. brand, 13c.
Cookson's "C" grade, 13@13¼c.
Chinese needle, lump, nominal, 8½@9c.
White oxide, Chinese, 99 per cent Sb_2O_3, 11½@13c.

Bismuth—$1.85@$1.90 per lb. London, 7s. 6d.

Cadmium—60c. per lb. London, 2s. 6d.

Cobalt—$2.50@$3 per lb. for spot.

Iridium—$260@$270 per oz.
Iridium alloyed with platinum, $280 @$286.

Nickel—27½@28½c. per lb. for 99 per cent virgin metal. London, £135 long ton.

Osmiridium—Crude, $58.50 per oz.

Osmium—$95@$104 per oz.

Palladium—$78@$83 per oz. Crude, $60 per oz.

Platinum:
Refined, Sept. 11, 12, 13, $120; Sept. 15, 16, and 17, $118 per oz.
Crude, $112@$114.

Quicksilver—$73 per 75-lb. flask. San Francisco wires $71.35; London, £13¼.

Rhodium—$85@$90 per oz.

Ruthenium—$40@$45 per oz.

The prices of Germanium Oxide, Magnesium, Molybdenum, Monel Metal, Radium, Selenium, Tellurium, Thallium, Tungsten and Zirconium are unchanged from the prices given in the Sept. 6 issue.

Metallic Ores

Chrome—$19@$24, depending upon grade and source. Nominal.

Manganese—42@46c. per long ton unit, seaport, c.i.f. Nominal.

Molybdenum—70c. per lb. of MoS_2 for 85 per cent concentrates. Nominal.

Tungsten Ore—Per unit, N. Y.:
High-grade wolframite, $8.50@$8.75.
High-grade scheelite, $9.
Ordinary grades, $8.25@$8.50. Nominal.

Iron Ore, Magnetite, Tantalum, and Vanadium are unchanged from Sept. 6 quotations.

Lower Offering for Lead—Zinc Steady

Joplin, Mo., Sept. 13, 1924

Zinc Blende

	Per Ton
High	$45.65
Premium, basis 60 per cent Zn	$44.00
Prime Western, 60 per cent Zn	$43.00
Fines and slimes	$42@$40.00
Average settling price, all	$43.01

Lead Ores

High	$112.00
Basis 80 per cent lead	$110.00@$107.50
Average settling price, all	$108.60

Shipments for the week: Blende, 14,048; lead, 1,592 tons. Value, all ores the week, $777,070.

Offerings of $107.50 basis were made today by at least one lead buyer, but no ore is reported sold at that price.

Sales of zinc on $42 basis were reported in the middle of the week, the ore selling at that price being low grade and high in lead—a few lots that had been in no demand—but the purchase of this tonnage will lower the visible stock and remove a menace to stable prices. Twelve thousand three hundred and ninety tons was purchased this week, the bulk of which sold on $43 basis.

Platteville, Wis., Sept. 13, 1924

Zinc

	Per Ton
Blende, basis 60 per cent zinc	$45.50

Lead

Lead, basis 80 per cent lead	$112.00

Shipments for the week: Blende, 577 tons; lead, none. Shipments for the year: Blende, 21,718; lead, 720 tons. Shipments for the week to separating plants, 1,192 tons blende.

Non-Metallic Minerals

Asbestos:
Crude No. 1—$300@$325.
Crude No. 2—$150@$200.
Spinning fibers—$90@$125.
Magnesia and compressed sheet fibers —$50@$90.
Shingle stock—$45@$55.
Paper stock—$25@$40.
Cement stock—$15@$25.
Floats—$6@$12.
All per short ton, f.o.b. mines, Quebec, tax and bags included.

No. 1 Rhodesian crude, $280; No. 2, $175 per short ton, c.i.f. New York.

Fluorspar — F.o.b. Middle Western mines, per net ton:

Gravel, not less than 80 per cent CaF_2 and not over 5 per cent SiO_2, $17.50.

Gravel, not less than 85 per cent CaF_2 and not over 5 per cent SiO_2, $18.50.

Lump, not less than 85 per cent CaF_2, not over 5 per cent SiO_2 $18.50.

Ground, 93 to 98.5 per cent CaF_2 and not over 3 per cent SiO_2, $35 in bulk, $39 in bags or barrels.

Acid, ground, not less than 98½ per cent CaF_2 and not over 1 per cent SiO_2, $45 in bulk, $49 in packages.

Amblygonite, Barytes, Bauxite, Beryl, Borax, Celestite, Chalk, China Clay, Diatomaceous Earth, Emery, Feldspar, Fuller's Earth, Garnet, Gilsonite, Graphite, Gypsum, Ilmenite, Lepidolite, Limestone, Magnesite, Manjak, Mica, Monazite, Ocher, Ozocerite, Phosphate, Potash, Pumice, Pyrites, Rutile, Silica, Spodumene, Sulphur, Talc, Tripoli and **Zircon** are unchanged from Sept. 6 prices.

Mineral Products

Arsenious Oxide (white arsenic)— 7½c. per lb. Market quiet.

Copper Sulphate—4.75c. per lb. for domestic in carload lots.

Potassium Sulphate, Sodium Sulphate, Sodium Nitrate and Zinc Oxide are unchanged from Sept. 6 prices.

Ferro-Alloys

Ferromanganese—$95 per gross ton.

Ferrotungsten — Domestic, 88@90c. per lb. contained tungsten.

Ferrochrome, Ferromolybdenum, Ferrosilicon, Ferrotitanium, Ferro-uranium and Ferrovanadium are unchanged from the prices given in the Sept. 6 issue.

Metal Products

Copper Sheets, Lead Sheets, Nickel Silver, Yellow Metal and **Zinc Sheets** are unchanged from Sept. 6 prices.

Refractories

Chrome Brick—$45@$47 per net ton, f.o.b. Chester, Pa.

Firebrick — First quality, $40@$43 per M, Central Pa. works, Southern Ohio and Kentucky; second quality, $33@$37.

Magnesite Brick—$65@$68 per net ton, Chester, Pa.

Silica Brick—$35@$38 per M., Pa.; $48@$50, Birmingham.

Bauxite Brick, Magnesite Cement, and **Zirkite** are unchanged from Sept. 6 prices.

Iron Trade Quiet

Pittsburgh, Sept. 16, 1924

Though production of steel ingots showed the remarkable increase of 36 per cent from July to August, the course of finished-steel shipments has been steadier, not dropping so low in July or rising so high in August. They were about 45 per cent of capacity in July, rising to fully 50 per cent in August as a whole, and in the first half of September they have been close to 60 per cent.

Finished-steel prices have undergone no quotable change for nearly three weeks, but several lines are a shade easier without being openly or generally quoted at lower levels.

Pig Iron—The market continues quiet, with prices unchanged at $20 for bessemer, $19 for basic, and $20 for foundry, f.o.b. Valley furnaces. Steadiness is due to production being so light. Perry furnace, at Erie, has gone in; Adrian, at Dubois, is expected to go out.

Connellsville Coke—Dover furnace has contracted for Connellsville coke for the fourth quarter, about 14,000 tons monthly, at the recently established price of $3.25, and there is little more business in sight. Spot is $3@$3.15, with spot foundry at $4@$4.50.

Mining Stocks

Week Ended September 13, 1924

Stock	Exch.	High	Low	Last		Last Div.
COPPER						
Alaska-Br. Col.	N. Y. Curb	...	...	*37	...	....
Anaconda	New York	38¼	36⅝	36⅞	De.15, Ja.21, Q	0.75
Arcadian Consol.	Boston	1⅞	1¼	1½	...	....
Ariz. Com'l.	Boston	10⅝	10	10	Jy.19, Jy.31	0.50
Calaveras	N. Y. Curb	...	...	2	...	....
Calumet & Arizona	Boston	52	50⅜	51½	Se. 5, Se. 22 Q	0.50
Cal. & Hecla (New)	Boston	16⅜	16⅛	16⅛	My. 31, Jn. 16	0.50
Canario Copper	N. Y. Curb	4	3⅞	4	...	....
Cerro de Pasco	New York	46⅛	45⅜	45⅞	Jy. 17, Au. 1	1.00
Chile Copper	New York	34	32⅛	33⅜	Se.3, Se.29, Q	0.62½
Chino	New York	21	20⅛	20½	Sept., 1920,	0.37½
Con. Coppermines	N. Y. Curb	3 1/16	3⅛	3 3/16	...	....
Copper Range	Boston	26¼	24¼	24¾	May, 1923	1.00
Crystal Copper	Boston Curb	*65	*60	*60	...	....
Davis-Daly	Boston	*45	*45	*45	Mar., 1920	0.25
East Butte	Boston	4⅜	4¼	4½	Dec., 1919	0.50
First National	Boston Curb	*39	*38	*38	Feb., 1919,	0.15
Franklin	Boston	*50	*50	*50	...	....
Gadsden Copper	Boston Curb	*70	*70	*70	...	....
Granby Consol.	New York	18⅞	17⅛	18	May, 1919	1.25
Greene- Cananea	New York	15⅞	15⅛	15⅞	Nov., 1920	0.50
Hancock	Boston	...	...	1½	...	....
Howe Sound	N. Y. Curb	2⅛	2⅛	2⅜	Ap.1, Ap.15, Q	0.05
Inspiration Consol.	New York	27⅛	26⅝	26⅞	De.20, Ja.7, Q	0.50
Iron Cap	Boston Curb	...	...	3	May, 1923	0.15
Isle Royale	Boston	15	14¼	14⅛	Se. 1, Se. 15,	0.50
Jerome Verde Dev.	N. Y. Curb	1⅛	*96	1⅛	...	....
Jib Consol	N. Y. Curb	*67	*52	*60	...	....
Kennecott	New York	47⅞	46½	46⅞	Se.5, . Oc.1, Q	0.75
Keweenaw	Boston	...	...	*80	...	....
Lake Copper	Boston	2	1½	1½	...	....
Magma Copper	New York	36	34½	35¼	Jan., 1919	0.50
Mason Valley	N. Y. Curb	1⅝	1⅝	1⅝	...	....
Mass Consolidated	Boston	1¼	1	1	Nov., 1917	1.00
Miami Copper	New York	23	22	22	Au 1. Au.15, Q	0.15
Mohawk	Boston	36	33½	34	Se. 22, Oc. 13,	1.00
Mother Lode Coa.	New York	8½	8	8	Jn.13, Jn.30	0.37½
Nevada Consol.	New York	14½	14	14	Sept., 1920,	0.25
New Cornelia	Boston	21	20⅜	21	Au.8, Au.25,	0.25
New Dominion	N. Y. Curb	...	...	2⅜	...	....
North Butte	Boston	4⅞	4½	4⅛	Oct., 1918,	0.25
Ohio Copper	N. Y. Curb	1⅜	1 3/16	1 3/16	...	....
Old Dominion	Boston	22	22	22	Dec., 1918	1.00
Phelps Dodge	Open Mar.	†111	†107	...	Se.20, Oc.1 Q	1.00
Quincy	Boston	21¼	20¼	20½	Mar., 1920	1.00
Ray Consolidated	New York	13	12	12¼	Dec., 1920	0.25
Ray Hercules	N. Y. Curb	*18	*18	*18	...	....
St. Mary's Min. Ld.	Boston	37	36	36¼	Ap.22, My.20	3.00
Seneca Copper	New York	1⅜	1⅝	1⅜	...	....
Shannon	Boston	1½	*65	1⅜	Nov., 1917	0.25
Shattuck Arizona	New York	...	...	7⅛	Jan., 1920	0.25
Superior & Boston	Boston	*38	*25	*30	...	....
Tenn. C. & C. cfs.	New York	8⅛	7⅛	8	De.31, Ja.15, Q	0.25
United Verde Ex.	N. Y. Curb	26⅝	26⅛	26⅛	Jy.3, Au.1	0.50
Utah Copper	New York	76⅜	76⅛	76⅛	Se.15, Se.30, Q	1.00
Utah Metal & T.	Boston	*31	*25	*29	Dec., 1917	0.30
Victoria	Boston	...	...	50	...	....
Walker Mining	N. Y. Curb	...	...	3 1/16	...	....
Winona	Boston	*30	*30	*30	...	....
NICKEL-COPPER						
Internat. Nickel	New York	18	17⅜	18	Jy.17, Au.1, Q	1.50
Internat. Nickel pfd.	New York	88⅛	88⅛	88⅛	Jy.17, Au.1, Q	1.50
LEAD						
Carnegie Lead & Zinc	Pittsburgh	4½	4½	4½	...	....
National Lead	New York	152	147	149	Se.12, Se.30, Q	2.00
National Lead pfd.	New York	118	118	118	Au. 22, Se. 15, Q	1.75
St. Joseph Lead	New York	29¼	28⅞	29	Se. 9, Se.20	0.50
ZINC						
Am. Z. L. & S.	New York	9	8⅛	8⅛	May, 1920	1.00
Am. Z. L. & S. pfd.	New York	...	...	29	Nov., 1920	1.50
Butte C. & Z.	New York	5⅛	5	5⅛	Mar., 1922	0.50
Butte & Superior	New York	18	16⅞	17	Je.15, Je. 30, Q	0.50
Callahan Zn-Ld.	New York	3⅞	3¾	3⅞	Dec., 1920	0.50
New Jersey Zn.	N. Y. Curb	158	158	158	Aug. 9, 1924	2.00
United Zinc	N. Y. Curb	...	...	*25	...	....
Yellow Pine	Los Angeles	60	60	60	June, 1924	0.04
SILVER						
Alvarado	N. Y. Curb	...	...	*90	...	....
Beaver Consol.	Toronto	*16	*15	*15⅜	May, 1920	0.03
Castle-Trethewey	Toronto	*73	*72	*72½	...	....
Coniagas	Toronto	1.80	1.60	1.70	Ap.20, My.1	0.02½
Crown Reserve	Toronto	*50½	*48½	*50	Jan., 1917	0.05
Keeley	Toronto	2.31	2.20	2.28	Sept. 15, SA	0.12
Kerr Lake	N. Y. Curb	...	...	1⅜	Oc. 1, Oc. 15,	0.12½
La Rose	Toronto	*8	*7	*8	Apr., 1922	0.10½
Lorrain Trout Lake	Toronto	1.43	1.39	1.42	...	....
McKinley-Dar.-Sav.	Toronto	*12	*10	*11	Oct., 1920	0.03
Mining Corp. Can.	Toronto	2.85	2.72	2.80	Sept., 1919	0.12½
Nipissing	N. Y. Curb	6½	6⅜	6½	Jn.30, Jy.21, Q	0.15
Ontario Silver	New York	6⅞	6⅝	6⅝	Jan., 1919	0.50
Temiskaming	Toronto	*20	*20	*20	Jan., 1920	0.40
GOLD						
Alaska Gold	New York	*15	*13	*15	...	....
Alaska Juneau	New York	1⅛	1	1⅛	...	....
Argonaut	Toronto	*37	*32½	*35	...	....
Carson Hill	Boston	1	1	1	...	....
Cresson Consol. G	N. Y. Curb	3¼	3⅛	3⅛	Jn.30, Jy.10, Q	0.10
Dome Mines	New York	15⅛	15⅛	15⅛	Jn.26, Jy.21, Q	0.50
Golden Cycle	Colo. Springs	...	...	1.30	My.31, Jn.10 Q	0.03
Hollinger Consol.	Toronto	14.05	13.98	14.00	Se.18, Oc.6, M	0.05
Homestake Mining	New York	44	43¾	44	Se.20, Se.25, M	0.50
Kirkland Lake	Toronto	*19½	*18½	*19	...	....
Lake Shore	Toronto	3.93	3.87	3.90	Se.1, Se.15, Q	0.05
McIntyre-Porcupine	New York	16⅝	16⅜	16½	Au. 1, Se. 1,	0.25
Newray	Toronto	*24	*22	*23	...	....
Portland	Colo. Springs	...	...	50	Oct., 1920	0.01
Teck-Hughes	Toronto	1.27	1.25	1.25	...	....
Tom Reed	Los Angeles	19¼	18¼	18½	Dec., 1919	0.02
Tough-Oakes	Toronto	*62	*60	*61⅞	...	....
United Eastern	N. Y. Curb	...	...	*43	Jy.18, Jy.31, Q	0.05
Vipond Cons.	Toronto	1.32	1.27	1.28	...	....
Wright-Hargreaves	Toronto	3.90	3.60	3.75	Se.15, Oc.1, Q	0.02½
GOLD AND SILVER						
Black Oak	N. Y. Curb	*89	*89	*89	...	....
Con. Cortez	N. Y. Curb	*15	*12	*15	...	....
Con. Virginia	San Francisco	7½	7½	7½	...	....
Continental Mines	N. Y. Curb	...	...	2¼	...	....
Dolores Esperanza	N. Y. Curb	...	...	*50	Jy. 1, Jy. 10 Q	0.05
Premier Gold	N. Y. Curb	2⅛	2⅛	2⅛	Jn.19, Jy.2	0.08
Tonopah Belmont	N. Y. Curb	*63	*63	*63	Apr., 1923	0.05
Tonopah Divide	N. Y. Curb	*26	*26	*26	Se.22, Oc. 10	0.10
Tonopah Extension	N. Y. Curb	3 1/16	3 1/16	3 1/16	Se 10, Oc.1	0.05
Tonopah Mining	N. Y. Curb	2 1/16	2	2 1/16	Ap 6, Ap. 21	0.07½
Unity Gold	N. Y. Curb	1¼	1¼	1¼	...	....
West End Consol.	N. Y. Curb	*78	*67	*77	Mar., 1923	0.05
Yukon Gold	N. Y. Curb	...	...	*50	June, 1918	0.02
SILVER-LEAD						
Ahumada	Boston Curb	6⅞	6¼	6⅜	Se.16, Oc. 2, X	0.15
Bingham Mines	Boston	†17	†15½	...	Sept., 1919	0.25
Cardiff M. & M.	Salt Lake	...	...	*80	Dec., 1920	0.15
Chief Consol.	Boston Curb	2⅞	2⅞	2⅞	Ap 19, My.1, Q	0.10
Columbus Rexall	Salt Lake	15	15	15	Aug., 1920	0.03
Consol. M. & S.	Montreal	45	43½	45	Jn.30, Jy.15	0.75
Daly Mining	Salt Lake	2.00	2.00	2.00	July, 1920	0.10
Erupcion	Boston Curb	2⅜	2⅛	2⅜	Se. 15, Oc.2, X	0.15
Federal M. & S.	New York	...	...	12⅝	Jan., 1909	1.50
Federal M. & S. pfd.	New York	51½	49½	51	Au.25, Se.15, Q	1.75
Florence Silver	Spokane	8	6¼	6¼	Apr., 1919, QX	0.01
Hecla Mining	N. Y. Curb	9⅜	9⅛	9¼	Sept. 15, 1924	0.25
Iron Blossom Con.	N. Y. Curb	...	...	*21	Oct., 1923	0.02
Marsh Mines	N. Y. Curb	...	...	*5	June, 1921	0.02½
Park City	Salt Lake	4.45	4.45	4.45	Se.15, Oc.1,	0.15
Park Utah	N. Y. Curb	...	...	3⅛	Mc.15, Ap.1	0.15
Prince Consol.	Salt Lake	...	...	*7⅞	Nov., 1917	0.02
Silver King	N. Y. Curb	...	...	*50	Se.20, Oc.1,	0.15
Silversmith	Spokane	*33	*32½	*32½	Jy.1, Jy. 10,	0.01
Tamarack-Custer	Spokane	1.39	1.32	1.39	Se.22, Se.29,	0.25
Tintic Standard	Salt Lake	6.30	6.20	6.30	Jy.28 '24, X	0.25
Utah-Apex	Boston	2¼	2⅛	2⅛	Se.5, Se.15, Q	0.25
IRON						
Bethlehem Steel	New York	44⅞	43½	44⅜	Jn.1, Jy.1, Q	1.25
Char. Iron	Detroit	...	...	*40	...	....
Char. Iron pfd.	Detroit	*90	*90	*90	...	....
Colorado Fuel & Iron	New York	40⅜	36	40⅛	Au.11, Au. 25 Q	2.00
Col. Fuel & Iron pfd.	New York	...	...	108½	Feb., 1923	2.00
Gt. North'n Iron Ore	New York	30	28⅝	28⅝	De.10, De.27	2.00
Inland Steel	N. Y. Curb	....	....	46	Au.15, Se.1 Q	0.62½
Mesabi Iron	N. Y. Curb	....	....	2¾	...	....
Replogle Steel	New York	11⅞	11	11⅞	...	....
Republic I. & S.	New York	47⅜	45⅝	46¼	May, 1921	1.50
Republic I. & S. pfd.	New York	...	...	89	Se.15, Oc.1, Q	1.75
Sloss-Sheffield S.&I.	New York	71⅛	68⅜	71	Se.11, Se.20, Q	1.50
Sloss-Shef. S.&I.pfd.	New York	91	90	91	Se.20, Oc.1, Q	1.75
U. S. Steel	New York	108⅛	105⅜	107⅛	Se.1, Se.29 QX	1.75
U. S. Steel pfd.	New York	121⅛	121	121⅞	Au. 5, Au. 30 Q	1.75
Virginia I. C. & C.	New York	...	...	37⅛	De.15, Ja. 2	1.50
Virginia I.C.&C.pfd.	New York	...	...	71	Jn.17, Jy.1	2.50
VANADIUM						
Vanadium Corp.	New York	26⅛	24¾	25⅝	Jan., 1921	1.00
ARSENIC						
Western Utah Copper	N. Y. Curb	...	...	*17	...	....
ASBESTOS						
Asbestos Corp.	Montreal	27	27	27	Se.29, Oc.15 Q	1.00
Asbestos Corp. pfd.	Montreal	68⅛	66	68⅛	Oc.1, Oc.15, Q	1.50
SULPHUR						
Freeport Texas	New York	8	7⅛	7⅞	Nov., 1919,	1.00
Texas Gulf	New York	77⅜	75⅛	76½	Se.2, Se. 15, QX	1.75
PLATINUM						
So. Am. Gold & P.	N. Y. Curb	...	...	3⅜	...	....
MINING, SMELTING AND REFINING						
Amer. Metal	New York	46⅞	45⅛	46⅛	Au. 18, Se. 2 Q	0.75
Amer. Metal pfd.	New York	...	...	112	Au.20, Se. 2, Q	1.75
Amer. Sm. & Ref.	New York	74⅜	72	73⅜	Jy.11, Au.1, Q	1.25
Amer.Sm.&Ref.pfd.	New York	104⅜	103⅛	103⅝	Jy.11, Au.1,	1.25
U. S. Sm. R. & M.	New York	33	30½	32⅜	Jan., 1921,	0.50
U.S. Sm. R.&M.pfd.	New York	44	42⅞	44	Jy.7, Jy.15 Q	0.87½

* Cents per share. † Bid or asked. Q, Quarterly. SA, Semi-annually. M, Monthly. K, Irregular. I, Initial, X, Includes extra. The first date given is that of the closing of the books; the second that of the payment of the dividend.

Boston quotations courtesy Boston Stock Exchange; Toronto quotations those of the Standard Stock Exchange of Toronto, by courtesy of Arthur E. Moysey & Co.; Spokane, Pohlman Investment Co.; Salt Lake, Stock and Mining Exchange; Colorado Springs, Colorado Springs Stock Exchange.